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The Navy SEAL Physical Fitness Guide

Edited by Patricia A. Deuster, Ph.D., M.P.H.

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Department of Military and Emergency Medicine
Uniformed Services University of the Health Sciences
F. Edward Hebert School of Medicine

August 1997

Acknowledgments

The authors would like to recognize the invaluable contributions to the development of this guide by the following individuals. CAPT Kenneth Long participated in both panel reviews and provided useful suggestions and comments. His meticulous work was greatly appreciated by all. CAPT Peter Toennies reviewed and provided substantive comments about the chapter "Swimming for Fitness". Mr. Jeremy Levine and Ms. Brandi Schoeber provided information about strength training.

Importantly, we were extremely fortunate to receive valuable input from several SEALs throughout the development of this guide. ENS Frances Franky and BM1 George Vernia participated in the first panel review and their suggestions were incorporated in the second draft of the manual. BM1 Vernia helped organize and participated in the second and final panel review. Other SEAL panel reviewers included CW03 John Shellnut, Master Chief Bob Bender, LCDR Pat Butler, and BMCS Duane Noel. Each one of these SEALs provided suggestions and practical recommendations which were instrumental in the finalization of the *"The Navy SEAL Physical Fitness Guide"*.

About the Authors

CAPT Frank K. Butler, Jr., M.D., developed the chapter "SEAL Mission-Related Activities". He is currently the Biomedical Research Director for the Naval Special Warfare Command, Chairman of the U.S. Special Operations Command Biomedical Initiatives Steering Committee, and a Staff Ophthalmologist at the Naval Hospital, Pensacola, Florida. He obtained his undergraduate degree from Georgia Institute of Technology in 1971, with high honors. His medical degree is from Medical College of Georgia, 1980. Dr. Butler's Family Practice Internship was at the Navy Regional Medical Center, Jacksonville, Florida (1980-1981) and his Ophthalmology Residency was at the National Naval Medical Center, Bethesda, MD. where he was Chief Resident (1988-1989). He completed his Undersea Medical Officer Training from the Undersea Medical Institute, Groton, Ct., 1981. CAPT Butler has been a platoon Commander for Underwater Demolition Team TWELVE and SEAL Team ONE, and a Diving Medical Research Officer at the Navy Experimental Diving Unit. He has published extensively and been a frequent guest lecturer on the subject of closed-circuit diving and Special Warfare.

CAPT John S. Hughes, M.D., developed the chapter "Swimming for Fitness" and contributed to "Other Training-Related Issues". He is a Navy Reserve Undersea Medical Officer who resides near Littleton, Colorado. A graduate of the University of Colorado School of Medicine, Dr. Hughes has a Naval Reserve assignment to NAVSEA in Crystal City, Virginia, where he is assigned to the Supervisor of Diving and Salvage. Dr. Hughes has been involved with Navy diving medicine since 1981. He is Board Certified in Occupational Medicine and his civilian medical practice in Colorado and Wyoming involves operation of clinics and health facilities covering a wide range of high risk industries including commercial diving.

Special qualifications allow Dr. Hughes to participate in the development of the Navy SEAL Physical Fitness Guide. He swam freestyle in the NCAA Championships and won the 1976 Big 8 Conference Championship in the 1650 yd freestyle for the University of Colorado and has remained active as a competitive swimmer. As a mountaineer and cross country skier he has organized and participated in numerous climbs, including two on Denali and Denali North Peak in Alaska. His instrumental work with the SEAL team in developing a winter warfare program during 1982 led him to participate as a staff member of the SEAL winter warfare Greenland operation in 1983. For this involvement, Dr. Hughes received a letter of appreciation from the CO of SEAL Team TWO, CDR Rick Woolard. With the theme of Dr. Hughes' career being medical support of high risk military and industrial operations, he feels that work for the SEALs is at the head of the list.

CDR Joseph Moore, M.D., developed the chapter "Training and Sports-Related Injuries. He completed his undergraduate degree in 1978, and medical degree in 1982 from the University of Virginia after which he was commissioned as a Lieutenant in the Naval Medical Corps. CDR Moore completed his internship at Naval Medical Center, Oakland, California, in June 1983, and received orders to the 1st Marine Division, Camp Pendleton, California. He served as Battalion Surgeon, 2nd Battalion, 9th Marines from July 1983 to October 1985, deploying to Okinawa, Korea and Panama. He also served as 5th Marines Regimental Surgeon during this time period. He completed a Family Practice residency at the Naval Hospital, Camp Pendleton in 1987, followed by a tour as Senior Medical Officer on the island of La Maddalena, Italy. CDR Moore was the first Navy physician selected for a primary care Sports Medicine fellowship, and trained at the San Diego Sports Medicine Center and San Diego State University from December 1989 through January 1991.

CDR Moore is currently the Department Head and Fellowship Director for the Navy's Sports Medicine program at the Naval Hospital and Marine Corps Base, Camp Pendleton. In addition to his duties as Specialty Leader to the Surgeon General, Dr. Moore serves as chairman of the Sports Medicine Advisory Panel to the U.S. Naval Special Warfare Command, Coronado, and advisor to Marine Corps Combat Development Command, Quantico. His work with the civilian community has earned him an appointment by the Governor of California to the Governor's Council on Physical Fitness and Sports. He also holds an appointment to the United States Olympic Committee Team Physician Development Program, Colorado Springs, CO. He is co-chairman of the American Academy of Family Physicians' Review Course for Sports Medicine.

CDR Brad L. Bennett, Ph.D., developed the Chapter "Load Bearing" and he has written a technical report "Load Carriage: Are You Preparing Correctly? Naval Medical Research Institute, Technical Memo 96-71, 1991". He is a research physiologist currently assigned to the

Department of Military and Emergency Medicine, School of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD. He serves as an Assistant Professor and Director of the Basic Sciences Division. He is a graduate of Wilderness Medicine, and Tactical Emergency Medical Technician courses, and is a department faculty member in the Counter Narcotics Tactical Operations Medical Support (CONTOMS) course as sponsored by the Department of Defense. He earned a Bachelor and Master Degrees in Exercise Science from San Diego State University and a Ph.D. in Kinesiology from the University of Maryland.

He has completed the Navy's diving medicine course and became designated as a Navy Medical Department Deep Sea Diving Officer. He has conducted biomedical research on the impact of environmental stressors on human performance of Navy Special Warfare (SEAL) personnel, U.S. Marine Corps personnel, and Navy damage control personnel. Dr. Bennett currently serves as the Special Advisor to Navy Surgeon General for Physiology.

Dr. Bennett has enjoyed long distance running (10k, half marathons and marathons) for over twenty years. Other hobbies of interest are hiking, kayaking, camping, weight training, target and skeet shooting.

LCDR Lisa Thorson, M.D., wrote the Chapters on Flexibility, Calisthenics and Plyometrics. She earned her B.S. in psychology at the University of Oklahoma in Norman, Oklahoma, and her M.D. from the University of Oklahoma School of Medicine. She has completed the Undersea Medical Officer course and had a tour of duty at the Diver Second Class Training Department, Naval Amphibious School, Naval Amphibious Base, Coronado. LCDR Thorson been involved with the Exercise-Related Injury Program, and all aspects of injury prevention for the Special Forces Community. Projects have included the development of injury tracking software used by the Special Forces community. She also organized the first Naval Special Warfare Spots Medicine conference held May 1994. Recommendations from this conference are documented in Naval Health Research Center Technical Document Number 95-4D, "Naval Special Warfare Sports Medicine Conference Proceedings," and Number 95-5D, "Expert Panel Review of the Naval Special Warfare Calisthenics Sports Medicine Conference Summary."

Currently she is in Residency training in Preventive Medicine at the Uniformed Services University of the Health Sciences, Bethesda, Maryland, where her work documenting injuries in the Special Forces community will continue. She has 13 years of ballet training, has taught and competed in aerobic dance competitions, and spends her time weight-training.

Patricia Deuster, Ph.D., M.P.H., the editor of this guide, wrote "Cardio-respiratory Conditioning" and "Strength Training" and contributed to "Other Training-Related Issues". She compiled the group's recommendations and wrote the chapter "Physical Fitness and Training

Recommendations". She is an Associate Professor and Director of the Human Performance Laboratory in the Department of Military and Emergency Medicine at the Uniformed Services University of the Health Sciences, School of Medicine in Bethesda, Maryland. She has an undergraduate degree in Mathematics, and graduate degrees in Physical Education (M.A.), Nutritional Sciences (Ph.D.), and Public Health (M.P.H.). Her credentials for editing this book are many. She has been conducting research in the area of sports nutrition and exercise physiology for over 14 years, has published numerous papers on the nutritional needs of U.S. Navy SEALs, and has given many sports nutrition seminars to high school, college, and professional athletes, recreational athletes, SWAT teams, dietitians, and other health professionals. She is also an athlete herself. She was a tennis professional for five years and has competed in several triathlons and over 20 marathons; her best marathon time was a 2:48 in the Boston Marathon. Dr. Deuster was a nationally ranked runner for several years and a qualifier for the First Women's Olympic Marathon Trials. She is an avid sportswoman and a former skydiver who has logged in over 100 jumps.

Anita Singh, Ph.D., wrote "Overview of Physical Fitness" and "Running for Fitness" and assisted Dr. Deuster with the editing of this guide. She is an Assistant Professor in the Department of Military and Emergency Medicine at the Uniformed Services University of the Health Sciences, Bethesda, Maryland. Dr. Singh has a Ph.D. in Nutrition from the University of Maryland and she has been working in the area of Sports Nutrition and Exercise Physiology for over 10 years. In addition to looking at nutritional needs of U.S. Navy SEAL trainees, she has studied marathoners, ultramarathoners, and recreational athletes. She has presented her research work at various national and international meetings. Dr. Singh has published extensively in scientific journals and she co-authored "*The Navy SEAL Nutrition Guide*". She runs and plays tennis.

LDCR Kevin C. Walters, M.D., developed the chapter "Training for Specific Environments". He is a Diving Medical Officer at the Naval Special Warfare Center in Coronado, CA. Dr. Walters enlisted in the Navy in 1974 and graduated from BUD/S in 1976 (class 87) and served five and a half years at SEAL Team ONE. He left active duty in 1983 to return to college and graduate school. He received his M.D. degree in 1993 from the Uniformed Services University of the Health and subsequently completed a Transitional Internship at the Naval Medical Center, San Diego, CA.

CDR Steve Giebner, M.D., contributed to the chapter "Harmful Substances that Affect Performance". He is currently the Force Medical Officer for Commander, Naval Special Warfare Command. His association with the Naval Special Warfare community goes back to 1982 when he took his first operational assignment as the Diving Medical Officer

for the Naval Special Warfare Training Department of the Naval Amphibious School, Coronado. He is also plank owner at Naval Special Warfare Center as the first Medical Officer assigned to that command.

Dr. Giebner specialized in Sport and Exercise Preventive Medicine and Health Promotion, having earned the Master of Public Health degree in the Preventive Medicine residency at the University of California at San Diego and San Diego State University. He has long been an active proponent of Sports Medicine in the Navy, and especially within Naval Special Warfare His long association with Navy SEALs and his professional training uniquely qualify him to contribute to this manual.

In addition to recreational tennis, golf, and in-line skating, Dr. Giebner has consistently participated in command endorsed physical training programs throughout his Naval career. This year marks his first entry in the San Diego Marathon and a Superfrog Triathlon relay team.

HMC Denise E. Becker, USNR, developed "Appendix A - Weight Lifting Techniques" and assisted in the editing of this guide. She has a B.S. in Occupational Education and is pursuing a Masters degree in Exercise Physiology. She has served as the Training Chief and is currently assigned to Assault Craft Unit-4 Det 1 as Division Officer and the Medical Department Representative. An avid sportswoman, she has participated in several half marathons, 10 and 5K races, and triathlons. She competed in the Tidewater All-Navy Tennis Tournament. Chief Becker is married to a SEAL, Al Becker, LCDR, USN-RET and they have five children. The whole family has participated in the UDT/ SEAL Reunion Family Fun Run the past 10 years.

An Introduction by RADM Raymond C. Smith

Membership in the Naval Special Warfare (NSW) community requires an extraordinarily high level of total body physical fitness. A combination of muscular strength, flexibility and cardiovascular fitness is essential to carry out assigned missions.

To train most effectively for these physically demanding tasks, SEALs and others within the NSW community need clear, concise, and authoritative guidance on physical fitness training regimens. This manual, ***The Navy SEAL Physical Fitness Guide***, has been written to meet this need.

The authors of this comprehensive guide, physicians and physiologists, were chosen because of their special qualifications in the area of physical fitness and their knowledge of the NSW and SEAL community. Their expertise ensured the guide would be written with the unique requirements of the NSW community in mind, and that our goal of expanding the individual Navy SEAL's knowledge of attaining and retaining a high level of fitness would be achieved.

I commend ***The Navy SEAL Physical Fitness Guide*** as a superb source of information. Following the advice in this guide will enable SEALs and other members of the NSW community to prepare for the physically demanding missions to which they are assigned in the future.

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Introduction

The Navy SEAL Physical Fitness Guide has been prepared for the SEAL community with several goals in mind. Our objective is to provide you, the operator, with information to help:

- Enhance the physical abilities required to perform Special Operations mission-related physical tasks;
- Promote long-term cardiovascular health and physical fitness;
- Prevent injuries and accelerate return to duty;
- Maintain physical readiness under deployed or embarked environments.

If this guide is able to achieve those goals, it will be a major success. Being a SEAL is a tough job and requires enormous physical strength and stamina. Injuries, both chronic and acute are occupational hazards, but there are training measures and precautions that can be used to decrease the incidence of these injuries. Understanding the basics of physical fitness can go a long way to achieving these goals.

Physical fitness is typically considered a set of characteristics that people gain through various physical efforts. In fact, physical fitness consists of a variety of **measurable** components, some of which are skill-related and others which are health-related. The components of physical fitness are presented in Table I-1.

Table I-1. Skill- and Health-Related Components of Physical Fitness

Skill-Related	Health-Related
Agility	Cardiorespiratory endurance
Balance	Muscular endurance
Coordination	Muscular strength
Speed	Body composition
Power	Flexibility
Reaction time	

Definitions for each of these components/terms are provided in Chapter 1: Overview of Physical Fitness; all are extremely important in SEAL training. Because these components are measurable, it is clear that there are levels of physical fitness which can range from very low to exceptionally high. Moreover, a wide range may exist across particular components within an individual. For example, a person may have exceptional cardiorespiratory endurance, but have very poor flexibility. Thus, a high level in one component does not translate into high physical fitness. A highly fit person should achieve a high level in each of the health-related components for protection of health. However, for SEAL training, components of both skill and health-related groups are requisite. This guide should help you achieve a more favorable balance among the various components, and serve as a resource for you in the future.

Chapter 1
Overview of Physical Fitness

This chapter will introduce terms and definitions commonly used to measure or define fitness levels, and other terms associated with athletic training. Terms such as aerobic and anaerobic will be appearing throughout this fitness guide and various training techniques to optimize fitness will be discussed in greater detail in subsequent chapters. We suggest that you take some time to familiarize yourself with the terms and concepts in this chapter as this will greatly enhance your ability to apply the information provided in the remaining chapters.

Exercise Physiology

Exercise physiology is a branch of science which studies how the body responds and adapts physically to exercise training or to an acute bout of physical exertion. Such information is used for designing physical education, fitness and athletic programs. Physical fitness includes cardiopulmonary endurance, body composition, muscular strength and endurance, and flexibility.

Definitions and Terminology

Following are some commonly used exercise physiology terms and their definitions. You will come across many of these terms in subsequent chapters.

Aerobic: A process of producing energy that requires oxygen.

Aerobic Capacity: Total or maximal amount of aerobic work that can be done.

Aerobic Metabolism: Most of the energy needed to support exercise that goes beyond 3 minutes is provided by aerobic or oxidative energy metabolism. In other words oxygen is required to produce energy.

Agility: Ability to change physical position with speed and accuracy.

Anaerobic: A process of producing energy that does not require the presence of oxygen.

Anaerobic Capacity: Total or maximal amount of anaerobic work that can be done.

Anaerobic Glycolysis: A process of breaking down glycogen stores without oxygen; lactate (lactic acid) is the by-product of this process.

Anaerobic Metabolism: A type of energy metabolism that does not require oxygen.

Anaerobic Threshold: Transition point when aerobic metabolism can no longer meet the energetic demands, and energy from sources independent of oxygen are required. This is also the work rate at which blood lactate concentrations start to increase during graded exercise.

Adenosine Triphosphate (ATP): Energy released from food is stored in the muscle in the form of ATP. When ATP is broken down energy is released.

Balance: Ability to maintain equilibrium when stationary or while moving.

Cardiorespiratory Fitness: Ability of the heart, lung and blood vessels to transport oxygen and to remove waste products from the exercising muscle.

Concentric Contraction: Shortening of the muscle as it develops tension. This type of exercise is sometimes also known as "positive exercise".

Coordination: Ability to use the senses, such as sight, along with the functioning of a set of muscle groups to complete an activity accurately. For example: hand-eye coordination during rifle shooting.

Dynamic Exercise: Alternate contraction and relaxation of a skeletal muscle or muscles causing partial or complete range of movement through a joint.

Eccentric Contraction: Involves the lengthening of a muscle as it develops tension and is also known as "negative exercise". Eccentric contractions are used when resisting gravity as is the case in walking down hill or down stairs.

Electrocardiogram (ECG): A tracing that shows the electrical activity of the heart.

Ergometer: Instrument used to measure work and power.

Ergometry: Measurement of work and power during exercise.

Exercise: Planned, structured, and repetitive movements performed to improve or maintain components of physical fitness. The components include cardiorespiratory fitness, muscle strength and endurance, flexibility and body composition (see Introduction).

Fartlek Training: An unstructured type of interval training for speed-work.

Flexibility: Controlled range of motion of a specific joint. The range is a function of elasticity of the tendons, ligaments, and surrounding soft tissue. Control is a function of strength at each degree of motion, especially at the end ranges.

Glycogen: A form of carbohydrates that is stored in the liver and in muscles for energy.

Glycolysis: Breaking down of simple sugars into simpler compounds (chiefly pyruvate and lactate) for energy. This process is anaerobic.

Glycolytic: Pertaining to or promoting glycolysis.

Heart Rate: Number of heart beats per minute.

Interval Training: Very intense exercise bouts are alternated with rest or periods of low intensity exercise. Exercise during intervals is typically anaerobic.

Isokinetic: Contraction of a muscle or muscle group which results in joint movement at a constant angular velocity. For example: the arm stroke during free style swimming.

Isometric (Static): Muscle contracts without shortening or lengthening such that tension is developed but no muscular work is performed; energy is lost as heat. There is no joint movement during this type of exercise.

Isotonic (Dynamic): Muscle contracts and maintains constant tension by lengthening or shortening.

Lactic Acid (lactate): A by-product of anaerobic metabolism.

Ligament: A band of fibrous tissue that connects bone to bone or bone to cartilage so as to strengthen joints.

Maximal Oxygen Uptake (VO_{2max}): A measure of aerobic fitness: the maximal rate of oxygen uptake, and therefore aerobic energy utilization during exercise. Typically expressed as liters per minute or milliliters per kilogram (kg) body weight per minute (ml/min/kg).

MET (Metabolic Equivalent Unit): A unit used to estimate the metabolic cost of physical activity. One MET is the energy used by an individual at rest. This is equivalent to 3.5 ml of oxygen consumed per kg body weight per minute.

Metabolism: Physical and chemical processes that maintain life.

Minute Ventilation: Volume of air breathed per minute.

Muscular Endurance: Ability of a muscle or muscle group to contract at a submaximal force, usually against 50 to 60% of maximal resistance, over a period of time. Measured as the number of repetitions completed.

Muscular Strength: Maximal force or tension generated by a muscle or muscle group.

Myoglobin: An iron containing muscle protein that is responsible for the reddish color of various muscle fiber types.

Physical Activity: Movement by skeletal muscles that results in energy expenditure.

Physical Fitness: Ability to perform physical activity.

Plyometrics: Also known as explosive jump training. Muscles are rapidly stretched prior to contraction. Examples include standing jumps, multiple jumps, etc.

Power: Ability of a muscle to quickly generate force over a very short period of time. Examples include sprint starts, vertical jumps, kicks and throwing a punch.

Rating of Perceived Exertion (RPE): Measured using the Borg Category RPE Scale. As exercise intensity increases, the RPE increases and in general it is closely associated with physiological measures such as heart rate and oxygen consumption.

Reaction Time: Time taken between receiving a signal and reacting to it.

Respiratory Exchange Ratio: Ratio of carbon dioxide produced to oxygen consumed. An indication of the primary energy source used during exercise.

Speed: Ability to perform a movement in a short period of time.

Strength: Ability of a muscle to contract against resistance and provide control throughout the full range of motion.

Stroke Volume: Volume of blood pumped from the heart with each beat.

Tendon: A fibrous cord in which the fibers of a muscle end and by which the muscle is attached to a bone or other structure.

Tidal Volume: Volume of air moved during one breathing cycle while inhaling or exhaling.

Muscle Structure and Function

The three major types of muscle are:

- Cardiac muscle
- Skeletal muscle
- Smooth muscle

This discussion will be limited to skeletal muscles which, by converting chemical energy to mechanical energy, produce movement. We will present a description of the subtypes of skeletal muscles, including their characteristics and distribution. Although there may be many new subtypes of skeletal muscle fibers, generally skeletal muscle can be characterized into three basic types:

- Slow Twitch Oxidative (Type I)
- Fast Twitch Oxidative-Glycolytic (Type IIa)
- Fast Twitch Glycolytic (Type IIb)

Type I Muscle Fibers

Type I muscle fibers are involved in endurance activities. These fibers, also called **slow twitch fibers,** are noted for their ability to produce energy in the presence of oxygen. Thus, they are primarily aerobic. The main fuel source for this fiber is **fats (fatty acids)**, which allow the muscle to work at a steady rate with noticeable resistance to fatigue. Their color is typically quite red, a result of the high content of "myoglobin", an iron-containing protein that stores and delivers oxygen. Slow twitch fibers are not noted for their speed, their anaerobic capacity, or their ability to contract at a fast rate repeatedly, but rather their indefatigability and aerobic capacity.

Type II Muscle Fibers

Type II fibers can be categorized into at least two types: Type IIa and Type IIb. These fibers are adapted for strength and power activities. The **Type IIa fiber** is a cross between a slow twitch and a fast twitch fiber in that it is both aerobic (oxidative) and anaerobic (glycolytic). Whereas, it is "faster" than the slow twitch fiber, it is not as well suited for endurance activities. Its color is also reddish, a result of the myoglobin content.

In contrast, the **Type IIb fiber** is truly a fast twitch fiber, with very high contraction speeds. These fibers are almost exclusively anaerobic and have minimal capacity for aerobic production of energy. They rely primarily on glycogen within the muscle for energy and are therefore very susceptible to fatigue. Their color is pale, and some consider it "white" because it lacks myoglobin. Type IIb fibers tend to accumulate lactate, which ultimately leads to rapid fatigue if the lactate is not removed.

It should be noted that each of the fiber types has different recruitment patterns, and typically the Type IIb fiber is only recruited for use during maximal effort. The other fibers contract during light as well as moderate activity. **Moreover, physical training can lead to changes in the characteristics of the fibers.** Thus, endurance training would lead to changes in the Type IIa fiber such that they take on more characteristics of the Type I, or slow twitch fiber. Table 1-1 presents the distinguishing characteristics of the various fiber types.

Table 1-1. Distinguishing Characteristics of Major Muscle Fiber Types

Fiber Characteristic	Slow Twitch	Type II a Fast Twitch	Type II b Fast Twitch
Aerobic Capacity	High	Moderate/High	Low
Anaerobic Capacity	Low	High	High
Contraction Speed	Slow	Fast	Fast
Fatigue Resistance	High	Moderate/High	Low
Myoglobin Content	High	High	Low
Glycogen Content	Low	Moderate	High
Color	Red	Reddish-white	White

Distribution of Fiber Types

The amount of Type I and Type II muscle fibers in an individual is genetically pre-determined, and all normal skeletal muscle contains all fiber types. However, the proportion or distribution of these fiber types within and across individuals differs. Moreover, within an individual, the distribution of fibers in various muscles can vary widely. **Physical training may transform muscle fiber type, and the metabolic capacity of both type I and type II muscle fibers can be modified by endurance and power training.** It should be noted that performance depends not only on your fiber type composition, but also on the interplay between a variety of factors such as training, and diet, etc. Figure 1-1 represents the average percentage of slow twitch (Type I) fibers found in various subgroups of the population. As can be seen, persons whose activities are primarily endurance-related have a higher proportion of Type I fibers as compared to sprinters or wrestlers. Also in Figure 1-1 are the maximal aerobic capacities of these groups: the greater the proportion of Type I fibers, the higher the maximal aerobic capacity. Note the wide variability in the group of "recreational athletes". Specific types of training can induce changes in muscle fiber composition and characteristics.

Figure 1-1. Muscle Fiber Composition and Maximal Oxygen Uptake Values for Various Athletes by Sport

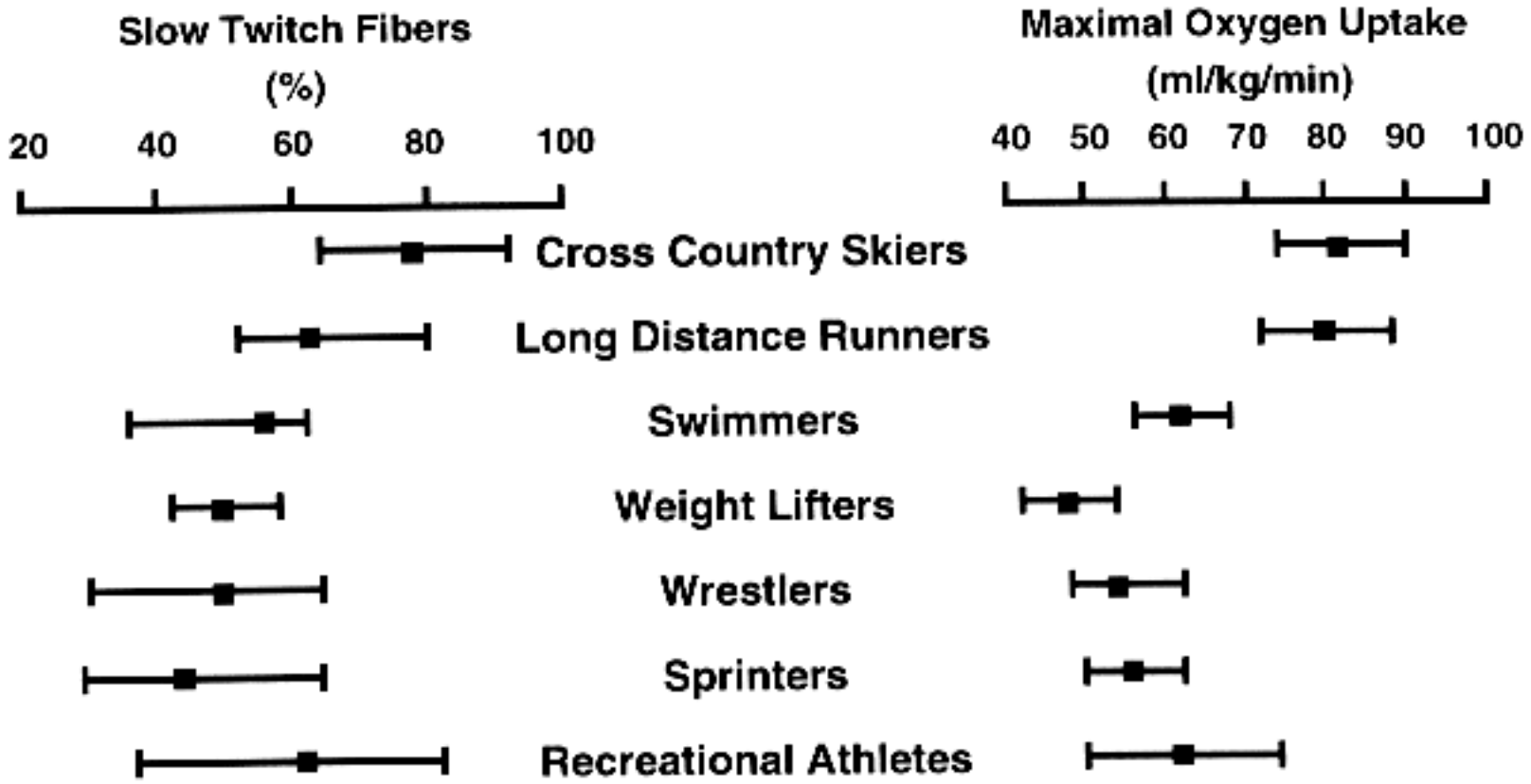


Figure adapted from: *Exercise Physiology: Energy Nutrition and Human Performance*, McArdle WD, FI Katch, VL Katch, 4th edition. 1996. Williams and Wilkins Publishers.

Principles of Physical Training

The goal of any training program is to improve performance. You are unique in terms of your excellent physical condition and your dedication to further enhancing your fitness. The four principles that apply to all physical training programs are discussed below.

Overload

According to this principle, exercise must be done at a higher level than usual to bring about various training adaptations. Once the body has adapted to the higher level of exercise it will function more effectively and efficiently. **The overload can be obtained by manipulating various combinations of exercise frequency, intensity, duration and type of**

exercise. Increasing intensity, duration and frequency can be helpful for running, cycling or swimming, and increasing resistance and repetitions can improve strength training.

Specificity of Training

This principle refers to the training-induced adaptations in metabolic and physiologic systems which are specific to the type of exercise. For example, running will increase physical fitness but it will not increase swimming performance and vice versa. Thus, it is important to train muscles involved in a specific type of exercise to realize greater performance benefits.

Individual Differences

Responses to a particular training program can vary from one individual to another. According to this principle, exercise programs should be individualized to meet the training requirements and physical capacity of each person.

Detraining

Regular exercise is necessary to maintain fitness. Beneficial effects of exercise are gradually lost or reversed after a few weeks off from training. This deconditioning or detraining effect will be discussed later in this chapter.

Because of the nature of your missions it is imperative that you develop all aspects of physical fitness: strength, speed, flexibility, and endurance. Therefore, it is important for you to consider your training in terms of the FITT principle.

FITT = Frequency, Intensity, Time & Type

All four aspects of the **FITT** principle must be included to achieve the most benefit from your training program. Number and intensity of workouts is important as is the time spent exercising and cross training (see Chapter 3). Information on how to determine your training intensity is provided next.

Determining Your Training Heart Rate

When reading the training methods presented in this chapter and throughout this guide, you will come across references to exercise intensity. **Intensity is the rate at which exercise is performed.** If you work out in a gym you may have used an exercise machine that monitors exercise intensity. A quick and easy method for measuring the intensity of your workout is by measuring your heart rate and checking to see if you are within your target training zone (see below).

Measure your heart rate by taking your pulse at the carotid artery (neck) or the radial artery (wrist) for 15 seconds; multiply this value by four to get your heart rate in beats per minute. Compare this heart rate value to your target training intensity. If your heart rate is too low, increase the intensity of your workout. If it is too high, reduce the intensity slightly.

Your target training heart rate can be calculated as follows:

To maintain aerobic conditioning, exercise should be performed at a heart rate between 70% and 90% of your **maximal heart rate (Max HR).**

Remember, this is only an estimate of your maximal heart rate.

Depending on your particular "physiology" and physical conditioning, your Max HR could be higher than what you derive from this equation. However, this is the way it is routinely estimated.

Max HR in beats per minute = 220 - your age (years)

To calculate 70% and 90% of your Max HR, multiply Max HR by 0.70 and 0.90, respectively. This is your target training intensity zone or the range within which your heart rate should be while working out. Figure 1-2 presents an example of how to calculate your desired training heart rate by this method.

Figure 1-2. An Example for Determining Your Target Training Heart Rate

Determining Your Target Heart Rate

A SEAL is 22 years old

Max HR = 220 - 22 = 198 bpm

Lower Target HR = 0.7 X 198 = 139 bpm

Upper Target HR = 0.9 X 198 = 178 bpm

Calculate your target training heart rate zone using the formula provided above or use the chart shown in Figure 1-3. It is important to note that maximal heart rates tend to be lower during swimming and arm exercises. For these activities you should subtract 13 from your maximal heart rate to before obtaining your training heart rate. An example of this is shown in Figure 1-4.

Figure 1-3. Target Training Heart Rate Zone

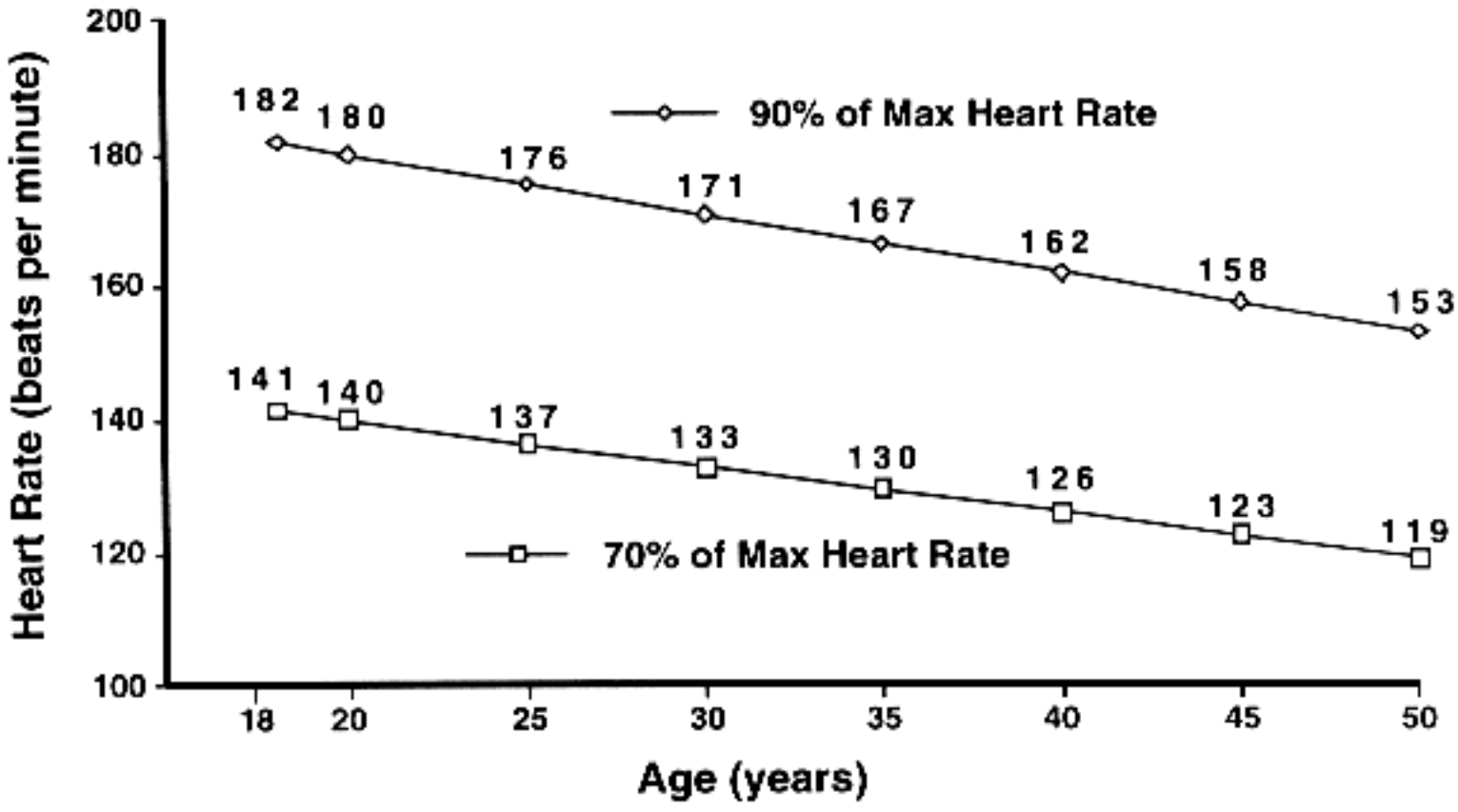


Figure 1-4. An Example for Determining Your Target Training Heart Rate for Swimming

A 22 year old SEAL wants to swim at 70% of Max HR

Then his Max HR = 220 - 22 = 198 -13 = 185 bpm

70% of Max HR = 0.7 X 185 = 130 bpm

Energy Systems Used by Exercising Muscle

Before describing the methods used for physical training, it is important to understand the three systems that provide energy to the exercising muscle. All three systems are important. Depending on the activity, there may be a greater reliance on one system over the others.

ATP-CP System for Speed Work

Adenosine triphosphate (ATP) is the immediate source of energy within all cells of our body for activities such as sprinting. There are small stores of ATP within skeletal muscle, and these energy stores provide immediate energy to sustain physical activities for a short time. Once the ATP is used, it breaks down into adenosine diphosphate (ADP). For regeneration of ADP into ATP for more energy, creatine phosphate (CP) is needed. It is the CP that regenerates the ATP. Without CP, ATP could provide energy for only a few seconds. With CP, the ATP-PC system can provide energy for about 30 seconds before other energy systems must take over. Thus, this ATP-CP system, sometimes referred to as the phosphate pool or reservoir, provides immediate anaerobic energy for muscle contraction.

ATP ⟶ ADP + Phosphate + Energy

ADP + CP ⟶ ATP + Creatine

Lactic Acid and ATP-CP System for Anaerobic Work

This is a transitional system. When all-out exercise continues beyond 30 seconds, the only way to continue providing ATP to the exercising muscle is by using sugar (glucose) in the muscle. Sugar in the muscle is obtained from glycogen, and the process of breaking down sugar for energy is called glycolysis. However, in the process of generating ATP from glucose, lactic acid (also known as lactate) is formed. Normally there is a only a small amount of lactate in blood and muscle. When lactate begins to accumulate in muscle and then blood, you will begin to experience muscular fatigue, unless it is cleared by the body. Lactate is cleared from the muscle if the intensity of the exercise is moderate. This happens because after a few minutes the aerobic or oxygen system, which supplies energy for sustained work, kicks in. If an all out effort is sustained, fatigue is inevitable within three to five minutes.

Oxygen System for Aerobic Energy

The oxygen, or aerobic, system provides energy to support long-term steady state exercise, such as long distance running or swimming. **Muscles can use both glucose and fatty acids for energy.** These fuel sources can be taken from the circulating blood and from stores within the muscle. Glucose is stored as glycogen and fatty acids are stored as "triglycerides" in the muscle. When long duration activities are performed at a slow pace more "fat" in the form of fatty acids is used for energy than muscle glycogen.

During many types of exercise, all three energy transfer systems are used at various times. The amount that each system contributes to energy metabolism is related to the duration, intensity and type of activity. In general, high intensity, short duration exercises rely mainly on anaerobic energy. Other examples specific to various activities are provided in Table 1-2.

Table 1-2. Percentage Contributed by Each Energy System to Overall Energy Needs of Various Activities

Physical Activity	ATP-CP System (%)	Lactic Acid and ATP-CP System (%)	Oxygen Aerobic System (%)
Marathon	-	5	95
Rowing	20	30	50
Running - 100 m	98	2	-
Running - 1 mile	20	55	25
Running - 3 miles	10	20	70
Running - 6 miles	5	15	80
Skiing Downhill - Racing	80	20	-
Skiing - Cross-Country	-	5	95
Swimming - 50 m	98	2	-
Swimming - 100 m	80	15	5
Swimming - 200 m	30	65	5
Swimming - 400 m	20	40	40
Swimming - 1500 m	10	20	70

Methods of Physical Training

Most people think of exercise as being either aerobic or anaerobic. However, in most types of exercise, a blend of both aerobic and anaerobic exercise is involved. For example, during a 1500 m run, energy is provided

by anaerobic metabolism at the beginning and the end of the run whereas aerobic metabolism supports the middle or the *steady state* part of the run. Aerobic and anaerobic capacity can be improved by using appropriate physical training techniques. The contribution of the three energy systems to the various training methods is shown in Table 1-3. The various physical training techniques are presented below, and can be used for enhancing performance during various physical activities.

Table 1-3. Contribution of the Various Energy Systems According to Training Methods

Training Method	ATP-CP System (%)	Lactic Acid and ATP-CP System (%)	Oxygen Aerobic System (%)
Interval Training*	10-80	10-80	10-80
Sprint Training	90	6	4
Acceleration Sprints	90	5	5
Interval Sprints	20	10	70
Fartlek Training	20	40	40
Continuous Running	2	5-8	90-93
Repetition Running	10	50	40

*Depends on rate and distance of exercise interval, type of relief interval and number of repetitions.

Interval Training

Exercise bouts are alternated with rest or relief periods. Relief periods usually involve mild to light exercise. Generally, in swimming no exercise is performed during the relief periods. The duration, intensity, and number (repetitions) of exercise bouts and the length and type of relief intervals are chosen to suit specific exercise performance requirements. Interval training allows you to exercise at a higher intensity than you could if you were

exercising continuously. This type of training helps to develop the muscle ATP-PC energy system. Both aerobic and anaerobic metabolism can be improved by interval training.

Sprint Training

Sprint training helps develop speed and increase muscle strength. Individuals are required to sprint repeatedly at maximum speed while allowing for complete recovery between sprints. In general, 6 seconds are needed to go from a stationary position to maximum speed. For a runner this would mean running 55 to 60 meters to reach that maximum speed.

Interval Sprints

This method involves alternately sprinting for 45 to 50 meters and jogging for 55 to 60 meters while covering a distance of about 3 miles. Interval sprinting helps to develop aerobic capacity.

Acceleration Sprints

Acceleration sprint training develops speed and strength. Running speed is gradually increased from jogging to striding to sprinting, followed by a recovery walk. This sequence is repeated. Intervals may range from 50 to 100 meters each. For example: 50 meters jogging, 50 meters striding, 50 meters sprinting and 50 meters walking.

Fartlek or Speed Play

The work *Fartlek* means "speed play" in Swedish. It involves running at fast and slow speeds on both level and hilly courses. Unlike interval training, the *fartlek* form of training does not involve specific exercise and rest periods; you do it as desired. For example, you may say to your buddy "I'll race you to the next stop sign", and you would both run as fast as you can to that point. You may run at a slower pace for a few minutes, and then run fast again for as long as you want. In other words, it is a speed workout without structure. As such, it is well suited to general conditioning and provides variety to workouts.

Continuous Exercise Training

This type of training is needed to build endurance for activities such as distance running and open ocean swimming. Exercise is performed with distance in mind and may be done at a slow or a fast pace. The aerobic

system is the main energy source for this type of activity. Specific training requirements for endurance training in running and swimming will be discussed in Chapters 4 and 5.

Repetition Running

This method is similar to interval training, but unlike interval training, the length of the intervals are longer and usually range from 0.5 to 2.0 miles. Recovery between intervals lasts until the heart rate is under 120 beats per minute, or within 60% of your estimated Max HR.

Conditioning and Deconditioning

Conditioning and deconditioning, also known as training and detraining, are responsible for gains and losses, respectively, in fitness levels. Whereas conditioning is a gradual process and may take six or more weeks to see specific effects, deconditioning occurs relatively quickly. Some of the various metabolic and cardiorespiratory effects of conditioning are presented in Table 1-4.

Table 1-4. Various Effects of Physical Conditioning

Metabolic Changes	Cardiorespiratory Changes
⇑ levels of ATP, CP, glycogen	⇑ in blood volume
⇑ levels of anaerobic enzymes	⇓ heart rate at given workload
⇑ capacity to tolerate blood lactate	⇑ stroke volume
⇑ levels of oxygen within muscle	⇑ ability to take oxygen from blood
⇑ levels of aerobic enzymes	improvement in blood pressure
⇑ capacity to use fat as fuel	⇑ ability to handle heat load

Effects of deconditioning will be noticed within one to four weeks. Deconditioning reverses the positive metabolic, cardiac, respiratory and muscle enzyme effects that result from conditioning. Some major effects of deconditioning include:

- Decrease in maximal aerobic capacity - Heart rate for a given exercise workload is higher and the amount of blood pumped by the heart with each beat is reduced.
- More rapid build up of lactic acid during exercise which leads to earlier fatigue.
- Reduction in levels of key muscle enzymes which regulate the muscle's ability to generate energy from various sources.
- Reduced ability to store glycogen in muscle between workouts.
- Reduced breathing volume which will decrease the amount of oxygen being taken to the exercising muscle
- Decreased endurance capacity - time to fatigue is shortened.
- Decreased ability to dissipate body heat during exercise: the ability to exercise in adverse environments, such as in the heat, is reduced due to all factors mentioned above.

Retraining is necessary to reverse the performance reducing effects of deconditioning. **However, deconditioning can be prevented or minimized by maintaining usual exercise intensity during endurance and strength workouts, when the number or length of work outs is decreased.** Aerobic capacity and decreased lactic acid accumulation during exercise can be maintained by training at least two to three times per week at your usual training intensity. Strength gains can be maintained by including one to two strength training workouts sessions per week. Specific training methods for maintaining fitness under deployed conditions and while overcoming an injury will be discussed in other chapters (see Chapters 11 and 12).

Active Recovery

This type of recovery means that you continue to exercise at a low to moderate (30% to 50% of your maximal heart rate) intensity for several minutes after your regular workout. For example, walk for 5 to 10 minutes after completing a run. The benefits of active recovery and additional information about this type of recovery are provided in Chapter 3: Cardiorespiratory Conditioning.

Chapter 2
SEAL Mission-Related Physical Activities

The primary goal of SEAL physical fitness training is to maximize mission-related performance. SEALs need a physical training program which encompasses all of the various mission-related tasks that need to be performed. Thus, before deciding on a physical fitness training regimen, the specific types of athletic activities involved in your missions must be clearly defined. It is important for you to establish specific goals. An athlete training for a marathon will want to train such that he will finish the race in the shortest possible time. Everything else in your program will be secondary to the primary objective of maximizing lower extremity aerobic performance. Likewise, a kayaker will maximize his aerobic performance by focusing on upper extremity conditioning. A competitive weight lifter, in contrast, will strive to maximize the amount of weight that he can lift, with little or no emphasis on endurance training.

What are "mission-related tasks?"

As an illustration, let's consider bicycling. Cycling is a superb way to obtain an intense aerobic (or anaerobic) workout and is very useful in promoting general cardiovascular fitness, but SEALs do not cycle during missions. No mission scenarios require you to hop on your bikes and ride 25 miles. In contrast, a two mile swim in fins also provides an excellent cardiovascular workout, and more closely approximates activities required on Special Warfare missions.

Although a good cardiovascular workout on a bike will confer a training benefit for SEALs, cycling is not the preferred substitute for mission-related training. Being in shape for one activity does not necessarily translate into being in shape for another activity which uses entirely different muscle groups. Training by running or biking to perform a long distance swim will result in a high incidence of muscle fatigue and leg

cramps on the mission. Some swimming must be incorporated into a training program. Moreover, swimming with fins on a regular basis will ensure that the operator is comfortable in his fins and wet suit booties, and prevent the development of painful blisters on the mission. Thus, there are many reasons for specificity of training.

Swimming is not the only mission-related task. The goal of this chapter is to present mission-specific activities and determine the physical tasks associated with these missions. **The doctrine that you should train as you fight is also true for physical fitness training.**

Mission-Specific Activities

What sort of physical activities will SEALs be required to perform in the course of their missions? To answer this question, the types of missions that you perform need to be examined. A partial list of these missions is shown in Table 2-1, and a brief description of these missions is provided below.

Table 2-1. A Summary of Various SEAL Missions

Types of SEAL Missions
Small Unit Patrolling
High Speed Boat Operations
Combat Swimmer Operations
SDV and Dry Deck Shelter Operations
Urban Warfare
Winter Warfare Operations

Small Unit Patrolling

One capability that will be needed in almost all SEAL land warfare operations is the ability to carry a substantial amount of weight over long distances. You will typically carry two weapons and a supply of ammunition. There is no good way to know exactly how much ammunition you will be required to carry for a particular mission and SEAL operators tend to pack heavy in this category. In addition, your loads will often include explosives

and specialized items. Water needs to be carried in the loadout and, if the mission is a sustained one, rations must also be included. Loads of 70-80 pounds are standard in the community and much heavier loads are not uncommon. How far must you carry this load? There is no one distance that can accurately be used as an upper limit, but certainly 10-20 miles in a 24 hour period, depending on the difficulty of the terrain, may be required for some operations. Walking long distances with a heavy load is a significant challenge in itself, but you may also be required to run and scramble over terrain features, walls, and fences.

Load-carrying is one of the most important physical activities a SEAL can practice.

The ability to carry a wounded fellow operator on your back or shoulders is also important. Buddy shoulder carries are critical in that they are currently the anticipated mode of transporting a wounded SEAL to a secure area where medical care can be rendered. These carries are somewhat different than long distance hikes with equipment because the load is distributed quite differently on the body and in some cases, the weight of the wounded operator may be in addition to the basic load.

How do you train for these activities? Long distance runs with shorts and running shoes are useful in promoting cardiovascular fitness, but do not adequately simulate load-bearing activities. Similarly, the number of bench presses you can do at a given weight does not ensure your being able to walk long distances with a heavy load. Moreover, some of the problems associated with load-carrying are musculoskeletal injuries and blisters. These can only be avoided (or minimized) by practicing the specific activity.

High Speed Boat Operations

The Special Boat Environment imposes unique physical demands. Such missions typically include extended periods in transit, often at high speeds in stormy seas. This type of activity requires extraordinary stability of the knee, elbow, shoulder and ankle joints. Since maintaining a slight bend in the knees, elbows and ankles is essential for minimizing musculoskeletal injuries, training to improve muscle strength and endurance is critical.

Combat Swimmer Operations

With the current-day SEAL teams having had their origin in the Scouts and Raiders, Naval Combat Demolition Units, and Underwater Demolition Teams of World War II, it is not surprising that combat swimmer operations are still an important part of the Naval Special Warfare mission. These operations may last as little as one or two hours in some situations, and as long as eight to 10 hours in others. You may be swimming on the surface or swimming underwater compass courses with the Dräeger LAR V or MK 16 closed-circuit underwater breathing apparatuses. These operations are often carried out in very cold water; thus, hypothermia is a constant concern. In many instances, you will be towing something in the water (usually something with a very rapid rate of combustion), thereby increasing the effort needed to accomplish the mission. Some missions involve exiting the water and climbing up the side of a ship using a caving ladder or other climbing apparatus. These are difficult maneuvers under any circumstances, but much more so when your hands are numb from cold exposure and you are climbing with weapons, ammunition, and explosives. **Regular exposure to cold water immersion will help to develop physiological adaptations so that you will fare better when subjected to cold water on a mission.** In addition, both upper body and leg strength are important for shipboarding techniques. **Grip strength, in particular, is critical for maintaining a firm hold on the rope or ladder.** Caving ladder or rope climbs are very important to develop the muscle groups that will be used for shipboarding; you should do these climbs with gear whenever possible.

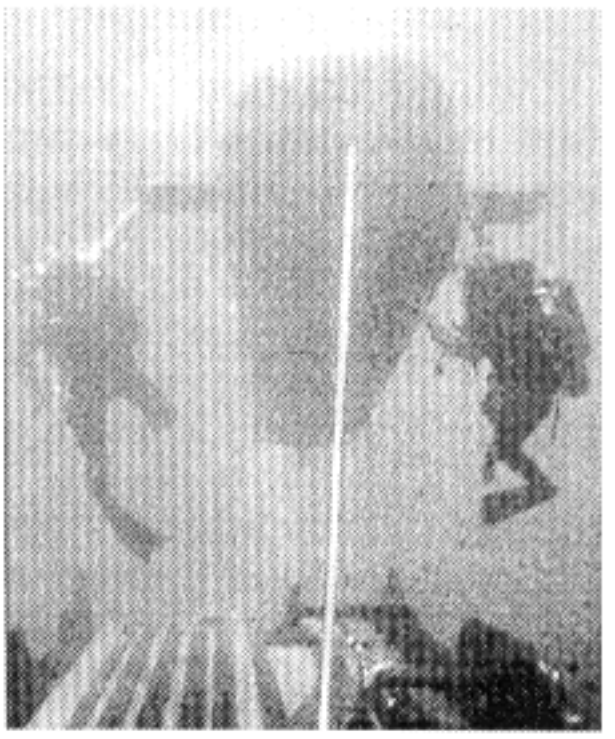
Swimming with fins is an activity basic to all SEAL combat swimmer missions and should be done on a regular basis in team physical training evolutions. Swimming without fins, while a very good activity for promoting cardiovascular fitness, is not typically required for SEAL missions. It is

important to mention that encouraging speed on combat swimmer operations is fine for surface swims, but should not be done on underwater swims because of the reduction in the LAR V operating range and increased risk of central nervous system oxygen toxicity.

High exercise rates under water increase the diver's chance of having an oxygen convulsion.

SDV and Dry Deck Shelter Operations

These operations are basically combat swimmer operations, but ones in which the SDV does the majority of the work. They are typically longer than operations in which free-swimming divers are used, but this is not always the case. As SDV operators, you need to be able to accomplish the same physical tasks noted for combat swimmers above. In addition, these operations may require significant upper body strength to handle the heavy equipment required for the mission both in the Dry Deck Shelter and later at the objective.



Urban Warfare

Some SEAL missions call for direct action operations in an urban setting. Although it is difficult to generalize, these missions might be expected to require less of a load-bearing challenge because some form of transportation will often be available. In addition, the distance to be covered on foot will typically be less than many remote missions. Generally, you will need to carry less food and water than with other types of land warfare missions. Your need for weapons and ammunition, however, will not be reduced, so significant gear loads are still a possibility. Additionally, you may need to perform demanding physical tasks, such as sprints and rapid stair climbs, in the urban warfare setting. Moreover, there is the potential of having to accomplish these maneuvers while carrying or dragging a wounded buddy or hostage.

Winter Warfare Operations

Winter Warfare operations often require long distance cross-country skiing or snowshoeing which will usually have to be done with a heavy equipment load. This activity requires the use of a different set of muscles than walking and running. Not all SEAL units have a primary mission area that requires the ability to operate in winter warfare environments, but those that do should consider cross-country skiing with equipment when designing their workout programs (see Chapter 14).

Specific Mission-Related Physical Tasks

In order to identify the physical demands of direct action SEAL operation, a study was undertaken in early 1990 by the Naval Health Research Center. Missions and the physical requirements (i.e., aerobic and anaerobic components) necessary to complete each mission and mission segment were evaluated. In brief, a total of 82 SEALs, averaging 11 years of experience, participated in the study. Subject matter experts from operational platoons were interviewed regarding missions they had conducted as SEALs. Information obtained during these interviews provided the basis for a questionnaire which was developed and given to the study participants. The questionnaire was composed of a list of missions and mission segments such

as "fast rope to the deck of a ship from a height of 40 feet, carrying a 50-pound pack." Each SEAL participant ranked mission and mission segments on scales to rank: difficulty of performance, frequency of performance, and importance to mission success. The individual scores for each scale were then summed to obtain a "composite score". Mission tasks that received the highest composite scores are provided below.

- Walk (i.e., hump) 15 km over uneven terrain at night carrying a 125 lb pack to objective in 70°F, then retrace steps to extraction point.
- Serve as point person for an element, walking a distance of 42 km through dense jungle in tropical heat and humidity over a 3-day period carrying a 60 lb pack and weapons.
- Swim a distance of 2,000 meters in 56°F carrying a limpet mine and using a Dräeger; return to Zodiac without limpet, then travel 6 km to extraction point.
- Swim for 3 hours underwater (temperature: 70°F), wearing a wet-suit, mask and fins, and using a Dräeger UBA and attack board.
- Drag a fully-loaded F470 Zodiac 50 meters onto a rocky beach with five other SEALs, then, with three of the boat crew, quickly move all equipment and supplies across 200 meters of rocky beach and stage/cache gear in preparation for the overland phase of the mission.
- Perform a rescue drag of a wounded comrade weighing 170 lbs, dragging him by the web gear a distance of 75 meters, with the assistance of one other SEAL.

Given the above list of missions tasks, the question **"what are the physical fitness requirements necessary to complete each task?"** was asked. A summary of the physical tasks data is presented in Table 2-2 and Table 2-3. Table 2-3 presents the numerous physical tasks associated with the missions and the physical characteristics demanded of the SEAL. Table 2-3 extends these characteristics by delineating specific training plans to improve performance on the physical tasks.

Table 2-2. Physical Requirements for Specific Missions and Mission Elements

Mission	Physical Tasks	Physical Requirements
Small Unit Patrolling	Sprint with gear Fast roping Load bearing Long distance hike "Over the beach" Buddy carry Rock climbing	Leg endurance Shoulder/arm strength Shoulder/arm endurance Upper back strength Grip strength
Combat Swimmer	Caving ladder climbs Underwater swimming Surface swimming	Shoulder/arm strength Leg endurance Grip strength
SDV/Dry Deck Shelter	Underwater swimming Heavy equipment handling	Leg strength/endurance Shoulder/arm strength
Urban Warfare	Buddy shoulder carry Climbing buildings Running/sprinting with gear Stair climbing	Shoulder/arm strength Leg strength/endurance Grip strength
High Speed Boats	Maintain joint stability at high speeds Extended periods in transit	Shoulder/arm strength Shoulder/arm endurance Leg strength/endurance Grip strength
Winter Warfare	Snow shoeing with gear Skiing with gear	Upper back strength Upper back endurance Leg strength/endurance Shoulder/arm strength Shoulder/arm endurance Grip strength

Table 2-3. Specific Physical Task-Related Training

Physical Tasks	Task-Related Training
Run/sprint with gear Load bearing Long distance hike "Over the beach" Buddy shoulder carry Obstacle negotiation with gear	Running/intervals Weight training Plyometrics Load-bearing hikes Grip strength
Fast roping Caving ladder Rock climbing Climbing buildings	Grip strength Rope climbs Squeezing tennis balls Weight training O'course
Swim with fins Underwater swimming Swimming with load	Surface swims Underwater swims
Snow shoeing Skiing with gear	Cross-country skiing Distance running Load-bearing hikes Weight training
Maintain joint stability at high speeds	Weight training Grip strength

The critical point in these tables is that your physical training program must be a whole body conditioning program with upper and lower body endurance, flexibility, and strength activities. Most missions involve multiple physical tasks, therefore, an effective training program must address the physical requirements of all these tasks. The training program provided in the last chapter has been designed with this goal in mind.

SEAL training must be whole body conditioning with upper and lower body endurance, flexibility, and strength activities.

Summary

The most important types of SEAL mission-related athletic activities are listed below. Each of these activities should be incorporated into a training program, ideally on a weekly basis. For other/substitute activities, please refer to Chapter 15: Physical Fitness and Training Recommendations.

- Long distance hikes with heavy equipment loads
- Cross-country skiing with equipment
- Caving ladder climbs with gear
- Swimming with fins
- Sprints with gear
- Obstacle negotiation with gear
- Fast-roping

For more information you may wish to consult the Navy Technical Report: No. 95-24 entitled: "Physical Demands of U.S Navy Sea-Air-Land (SEAL) Operations," WK Prusaczyk, JW Stuster, HW Goforth, Jr., T Sopchick Smith, and LT Meyer.

Chapter 3
Cardiorespiratory Conditioning

The American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention recently formulated new guidelines for the American public with respect to exercise. The new recommendations state that "*Every US adult should accumulate 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week*". They defined moderate intensity physical activity as "activity performed at an intensity of 3 to 6 METS, or the equivalent of brisk walking at 3 to 4 m.p.h. for most healthy adults". Whereas the previous recommendations for the US population emphasized the importance of extended periods of strenuous exercise, these new guidelines state that short, intermittent bouts of moderate exercise are important and sufficient for health benefits. The overall goal of these organizations is to promote cardiorespiratory conditioning, an important aspect of overall fitness, health, and disease prevention. However, activity above and beyond the recommendations for the public is necessary for SEALs and other highly competitive athletes. In this chapter we will discuss:

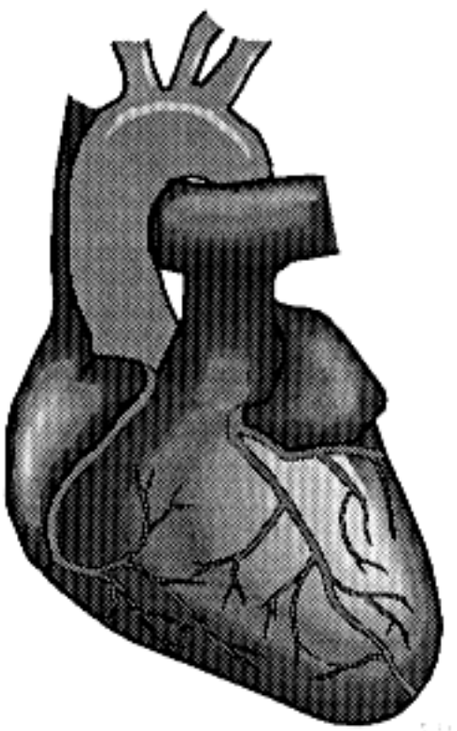
- Basic concepts of cardiorespiratory conditioning
- How to estimate your maximal aerobic capacity
- Types of aerobic activities and basic workouts

Many of the definitions and terminology associated with cardiorespiratory conditioning have been presented in Chapter 1. However, other terms are used interchangeably to reflect cardiorespiratory conditioning; these include cardiovascular, cardiopulmonary, and aerobic conditioning. The important point is that this form of conditioning improves health and work capacity by enhancing the circulation and overall functioning of the heart and lungs.

Basics Concepts of Cardiorespiratory Exercise

Cardiorespiratory conditioning consists of both aerobic exercise, which requires oxygen to sustain muscle activity, and anaerobic exercise, which does not use oxygen for the short bursts of highly intense activity. Most daily work and activities are aerobic in nature, and thus, improving the delivery of oxygen to the working skeletal muscle will improve work performance. Your ability to utilize oxygen for exercise depends on a variety of processes including:

- Functioning of your muscles of respiration or pulmonary ventilation
- Ability of oxygen to diffuse across lungs into your blood
- Ability of heart to increase rate of beating and amount of blood pumped with each beat
- Ability of blood vessels in and surrounding skeletal muscle to regulate blood flow
- Ability of contracting skeletal muscle to extract and use oxygen in blood



All of these factors are important in determining your ability to sustain a submaximal workload, and your maximal aerobic capacity. Two other factors which help determine maximal aerobic capacity are your percentage of specific muscle fiber types and your genetic makeup. Some persons are endowed with a high aerobic capacity, whereas others are not. However, everyone can and will improve if a cardiorespiratory conditioning program is followed.

Terms Related to Conditioning

Many terms are used to define or describe exercise conditioning and work rate, also referred to as exercise intensity or work load. The two terms used throughout this chapter for describing how to gauge your work rate will be maximal oxygen uptake and energy expenditure as calories/hour, or kcal/hr. Other terms to describe work rate and their interrelationships will be discussed at the end of this chapter.

Maximal Oxygen Uptake

The primary measure or predictors of one's capacity to sustain work performance is maximal oxygen uptake (VO_{2max}) or maximal aerobic (cardiorespiratory) capacity. VO_{2max} is measured in **milliliters per minute** (ml/min), **Liters/min**, or after adjusting for body weight in kilograms, as **ml/kg/min**; a higher value indicates a higher level of cardiorespiratory fitness.

Your maximal aerobic capacity or oxygen uptake is the best indicator of how much work you can sustain without fatigue.

Typical VO_{2max} values range from 30 ml (of oxygen)/kg/min for an unfit person up to 80 ml/kg/min for an exceptionally fit, endurance athlete. If the unfit and highly fit persons both weighed 70 kg (155 lb) then their respective absolute maximal aerobic capacities would be 2.1 liters (of oxygen)/min and 5.6 liters (of oxygen)/min.

Using 1 liter of oxygen/min is equivalent to expending 5 kcal/min

As such, the unfit person can only work at a rate of up to 10 kcal/min (2.1 L x 5) whereas the highly fit could work at up to 25 kcal/min (5.6 L x 5 kcal) if needed. If a specific task required 2 L/min, then this would amount to 10 kcal/min of energy. Resting energy expenditure requires less than one kcal/min, or about 0.200 to 0.250 L (of oxygen)/min. In order to account for different body sizes, resting energy expenditure for an individual is usually defined as:

3.5 ml of oxygen/kg body weight/minute.

Thus, for a 70 kg (155 lb) SEAL, resting energy expenditure would be approximately 245 ml/min or 0.245 L/min (3.5 x 70). This is equivalent to expending around 1 to 1.25 kcal/min.

Anaerobic Power

How much strenuous work can you sustain without oxygen? Most people can do very little for more than a couple of minutes. It is very important to realize that most people cannot work for very long at even 90% of their maximal aerobic capacity. This is because everyone has a threshold at which the balance between aerobic and anaerobic energy systems begins to favor the anaerobic; your muscles cannot extract enough oxygen to produce the required energy. This is called your **anaerobic threshold**; the turning point can be monitored by the accumulation of lactate in your blood. Of course, your body will know when there is too much lactate, because once lactate goes above a certain value, it starts to accumulate and unless you decrease your work rate, you will become too tired to continue working.

This anaerobic threshold, or "break point" varies among individuals, but ranges between 60% and 100% of your VO_{2max}; all SEALs should be able to work at 70% of their VO_{2max} for an extended period, and should have a break point above 70%. Conditioning programs for SEALs should strive to raise the anaerobic threshold or break point to as high as possible, because that means you can work at a higher rate for a longer period of time.

Interval workouts stress the anaerobic energy systems and will increase your anaerobic threshold and power.

Interval and fartlek workouts for running and swimming are described in their respective chapters, and such workouts for other forms of exercise are described later in this chapter.

Determination of Work Rate

One common denominator across all types of cardiorespiratory conditioning programs is exercise intensity and work rate. The term exercise intensity typically refers to how hard you are working as a percent of your maximal aerobic capacity. For example, you could work at an intensity equivalent to 50% (easy), 70% (moderate), or 90% (strenuous) of your maximal aerobic capacity or maximal heart rate. You will learn how to estimate your maximal aerobic capacity below, but on average, a maximal capacity of 45 to 55 ml of oxygen/kg/min and a maximal heart rate of 200 beats per min would be typical for a 20 to 29 year old SEAL. Table 3-1 presents the relation between exercise intensity, oxygen uptake, and heart rate for a 20 year old SEAL with a maximal heart rate of 200 and a maximal oxygen uptake of 55 ml of oxygen/kg/min. Easy exercise would use 25 to 30 ml of oxygen/kg/min or a heart rate of about 130 bpm, whereas strenuous exercise would require

a heart rate of around 180 bpm. However, you must know your maximal capacity or your maximal heart rate to actually quantify your exercise intensity in this way.

Table 3-1. Example of the Relation Between Exercise Intensity, Aerobic Capacity and Heart Rate

Exercise Intensity (% of Maximal)	Oxygen Uptake (ml/kg/min)	Heart Rate (bpm)
100% - Maximal	55	200
90% - Strenuous	50	187
70% - Moderate	39	160
50% - Easy	28	131

Factors Affecting the Training Response

The terms duration, frequency and intensity are commonly used when talking about training for fitness or health. All training programs, whether running, biking, swimming, or climbing, strive to vary in duration, frequency, and intensity so as to optimize conditioning and minimize injuries. Five major factors determine the extent of your maximal aerobic capacity and the magnitude of your response to training. These include:

- Initial level of aerobic fitness
- Duration of exercise
- Frequency of exercise
- Intensity of exercise
- Genetics/heredity

General principles apply to all types of physical activities. Take the following general principles and apply them to your individual program.

- The degree of aerobic training is closely tied to intensity and total work, not to frequency of training. However, a minimum of 3 days per week is recommended.
- A greater training improvement (up to a point) will be noted if you exercise above 85% of VO_{2max} or 90% of your maximal heart rate once a week or every other week: interval training.
- Aerobic capacity will improve if exercise increases your heart rate to at least 70% of your maximum heart rate.
- A lower exercise intensity can be offset by exercise of longer duration.
- Maximal heart rate for swimming and other upper body exercise is lower than maximal heart rate for leg or whole body exercise. Thus, training heart rate (THR) can be 13 to 15 bpm lower for swimming/upper body exercise than when running, biking, or other whole body exercises.
- A threshold duration per workout has not been identified to maximize aerobic capacity.

Active Recovery

Throughout this guide, we will continually stress the importance of warming up, cooling down, and stretching. These are integral parts of any workout, regardless of the activity. The cool down, or recovery period, is very important because it will determine how you feel several hours after your workout. There are two types of recovery: active and passive. Passive recovery, in other words, just resting, was recommended many years ago, and is still recommended when you exercise below 50% of maximal capacity. Active recovery is now preferred for exercise exceeding 60% of maximal capacity to accelerate removal of lactate. This may help prevent muscle cramps, stiffness, and preserve performance during subsequent strenuous exercise.

Active recovery involves exercising at 30% to 50% of maximal capacity for 5 to 10 minutes after a strenuous workout.

Blood lactate removal after strenuous exercise is accelerated by active recovery: mild aerobic exercise.

How to Estimate Your Maximal Aerobic Capacity

Exercise testing is often conducted for assessment of cardiorespiratory fitness. Types of protocols currently used to assess cardiorespiratory fitness or aerobic capacity are **incremental work rate tests**, where the exercise work rate is increased by a uniform amount at predetermined time intervals, and **constant work rate tests**, where the subject works at a submaximal constant work rate for a specified time period. Your heart rate at the specific work rates are used to estimate maximal oxygen uptake. Although the most accurate test is conducted on a treadmill, a bicycle will give a good estimate. If you have access to a stationary bicycle, you can test yourself by using the incremental test protocol described. Although it is best to use a heart rate monitor, you can manually take your pulse at various times during the test.

Bicycle Exercise Test Instructions

This test is an incremental submaximal test with four stages; each stage lasts two minutes. If desired, you can continue to increase the work rate and exercise for five to six stages. If you use a bike that monitors revolutions per min (RPM), your RPM must be maintained at 60. This seems like a slow pace, since you would usually bike at 70 RPM, but in order to achieve the desired work rate, 60 RPM pace is critical. Whatever type of bike you use, you must check to determine how to regulate **kcal/hr**.

Test Procedures

Adjust height of seat and handle bars to fit you, then if available, hook up a heart rate monitor and then start pedaling at a comfortable workload (See Table 3-2). If the bicycle permits, key in your body weight. This will make the test more accurate. After a couple minutes of warm-up, begin to exercise at level 1 or around 450 kcal/hr (± 25 kcal/min); record heart rate after two minutes (end of stage one). Increase the workload to level 2 or approximately 550 kcal/hr and continue for two more minutes. Remember that all stages are 2 minutes, so proceed to levels 3 (650 kcal/hr) and 4 (750 kcal/hr) at the appropriate time. The test should take no longer than 8 minutes, after warming-up. Record your heart rate at the end of each stage (Table 3-3).

DO NOT STOP Pedaling While Recording Your Heart Rate.

Table 3-2. Stages and Work Rates for Cycle Ergometer Exercise Testing

Stage	Work Rates
0	Warm-up
1	450 kcal/hr
2	550 kcal/hr
3	650 kcal/hr
4	750 kcal/hr

Table 3-3. Cycle Ergometer Test Form

Name:_____ Age:_____

Weight in kg*:_____ Estimated Max HR**:_____

Stage	Kcal/hr	Heart Rate
1	450	
2	550	
3	650	
4	750	

*To convert your weight from pounds to kg, divide by 2.2. **Estimate your maximal heart rate as 220 - your age.

Estimating Maximal Aerobic Capacity

Look at the example in Figure . Heart rate has been plotted against each energy expenditure. Estimate your maximal heart rate as 220 - YOUR AGE. Plot your heart rate values at each kcal/hr and draw the line of best fit through your points as in Figure (This should be a fairly straight line). Extend the line so you can also plot your estimated maximal heart rate on the line. Estimate your maximal aerobic capacity (in L/min), and then normalize for body weight: divide your VO_{2max} by your weight in kg. For example if your maximal oxygen uptake was 4.2 L of oxygen/min (4,200 ml)

as in the examples below, and you weigh 85 kg, your normalized maximal oxygen uptake would be 4.2 L or 4,200 ml/85 = 49 ml/kg/min. To convert your weight in lb to kg divide by 2.205. Normalizing for body weight allows you to determine how you rate relative to other persons of your age (Consult Table 3-4).

Example of How to Estimate Maximal Oxygen Uptake for an 85 kg, 24 year old SEAL

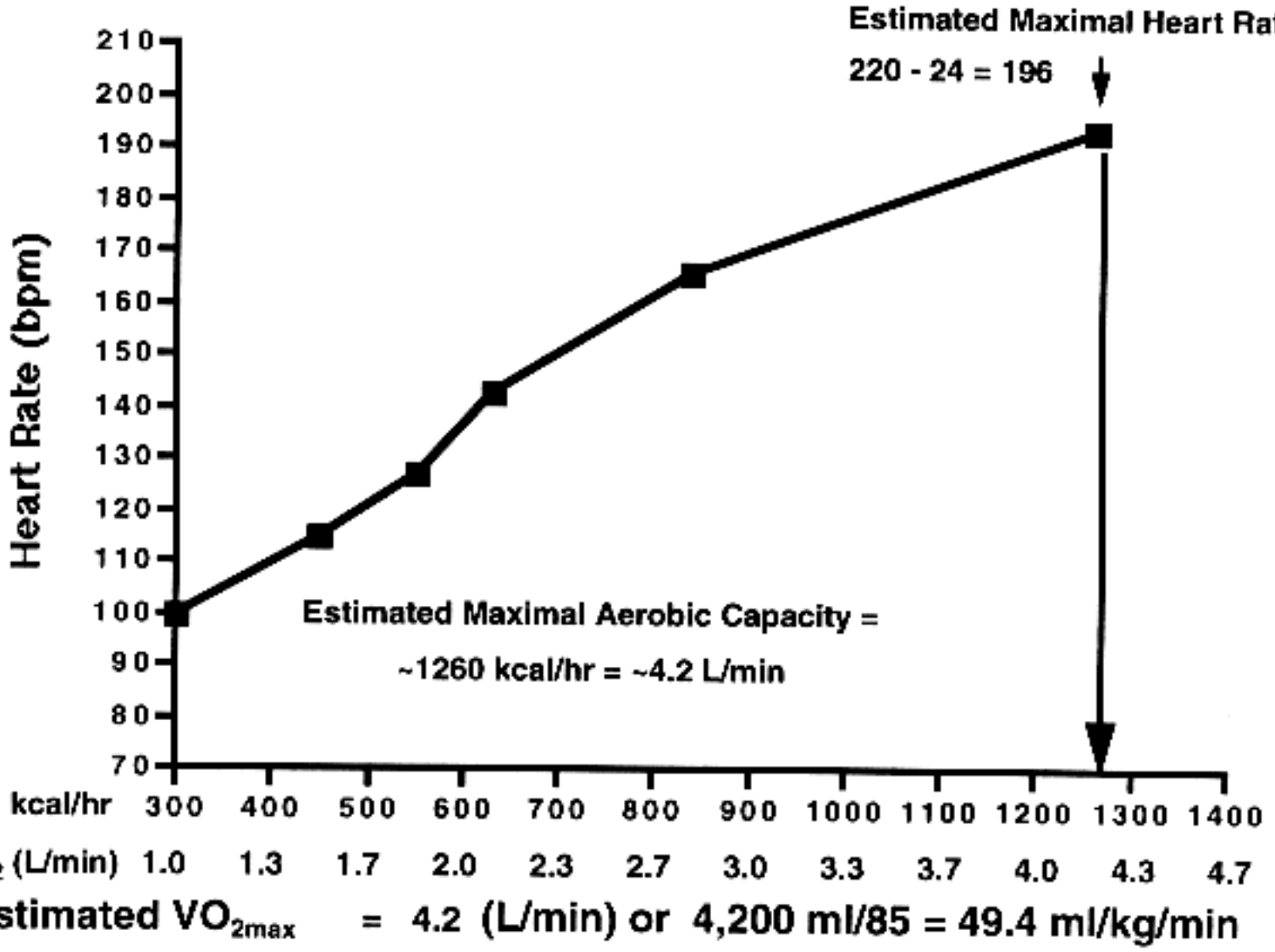
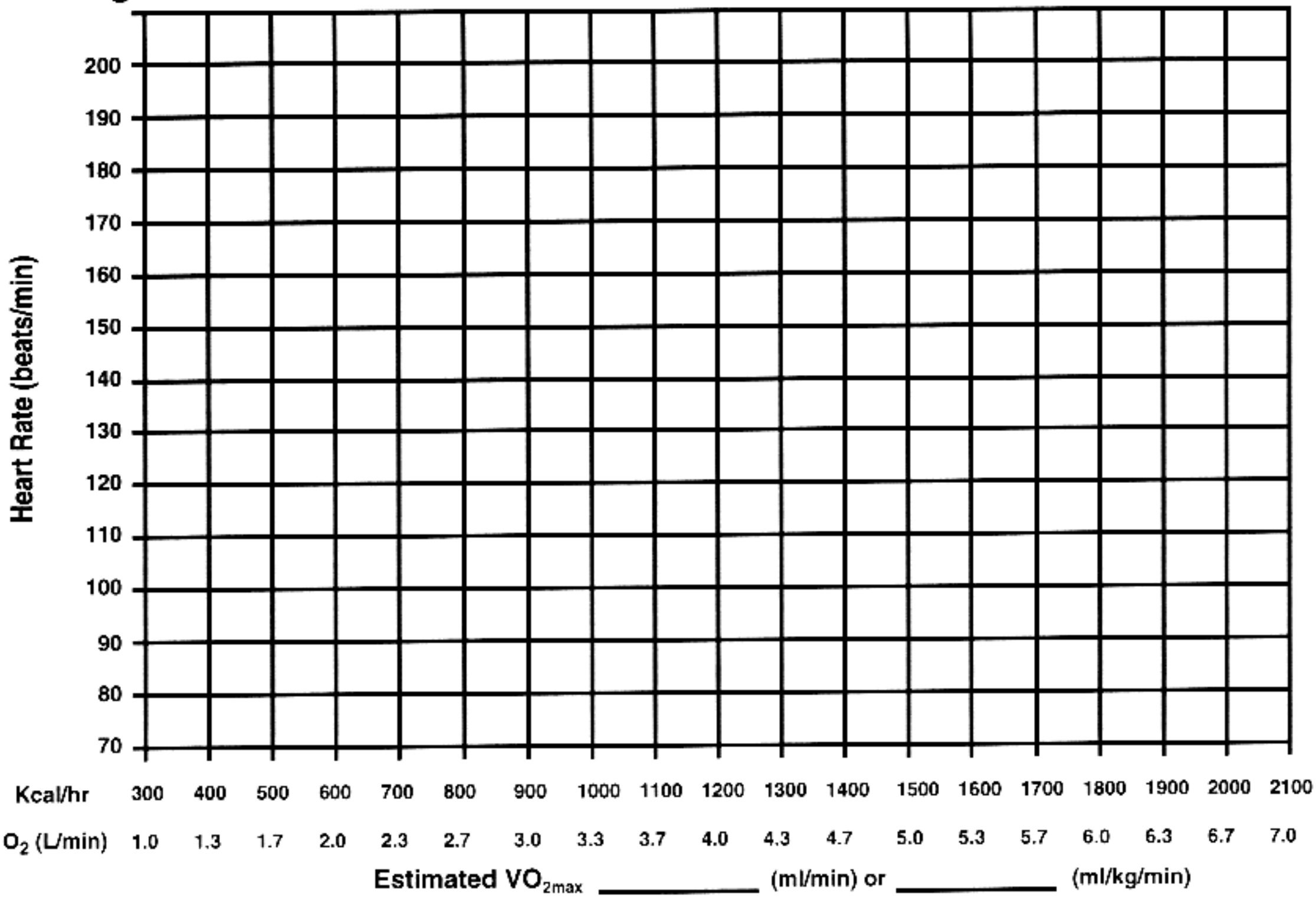


Table 3-4. Cardiorespiratory Fitness Classification: Maximal Oxygen Uptake (ml/kg/min)

Age	Low	Fair	Average	Good	High
20-29	<25	25-33	34-42	43-52	53+
30-39	<23	23-30	31-38	39-48	49+
40-49	<20	20-26	27-35	36-44	45+
50-59	<18	18-24	25-33	34-42	43+

Figure 3-1. Plot Your Heart Rate to Estimate Maximal Oxygen Uptake



Types of Aerobic Activities and Basic Workouts

Outdoor Activities

Aerobic activities, other than running and swimming, are briefly described below. More extensive discussions are provided in the section on indoor activities, since equipment used indoors typically has information about work rate and intensity. However, Table 3-5 presents the amount of energy expended per hour (kcal/hr) in these activities as a function of work rate. The values are for a 70 kg male. To get a more accurate estimate for yourself, multiple the number by your weight in kg and divide by 70.

Table 3-5. Typical Energy Requirements for Various Outdoor Activities

Activity	Work Rate	Energy Expenditure (kcal/hr
Bicycling	6 mph	270
	10 mph	420
	20 mph	720
Cross-Country Skiing	Moderate	504
	Strenuous, Uphill	1140
Jumping Rope	70 Jumps/minute	690
	145 Jumps/minute	840

Bicycling

Bicycle riding, or biking, is an excellent activity for improving overall cardiorespiratory fitness. Importantly, indoor bicycle ergometers have been used for many years to study the responses of the body to exercise. The work

rate you maintain while biking varies according to the terrain and your motivation. As such, biking outside offers many challenges. It is also a very efficient means of locomotion: the energy cost of biking is only 20% of walking, but you can travel almost five times faster on a bicycle. The quadriceps muscle in the front part of the thigh is the primary muscle for high rates of power output, and seat height can markedly affect overall muscle involvement. Although pedaling rates vary from 40 to 100 RPM, a rate of 70 appears to be the most comfortable.

A high pedaling rate offers advantages in terms of a high power output.

All in all, biking is a great alternative to running, and should be considered as a suitable activity for maintaining fitness, even if it is not part of a SEAL's mission. Biking complements other activities and is often used in rehabilitation from other musculoskeletal injuries. More details with respect to biking will be provided under the section on stationary cycles.

Cross-Country Skiing

Although cross country skiing is discussed in detail under winter warfare below, it should be noted that this is an excellent method of training for cardiorespiratory fitness. It engages almost all of the major muscle groups and thus, the overall energy expenditure may be as high or higher than when moving the body over the same distance on foot. Importantly, the intensity of the effort varies greatly as a function of the terrain: climbing uphill requires tremendous effort whereas going downhill represents a light load. High caliber cross-country skiers have some of the highest maximal oxygen uptakes ever recorded (see Chapter 2). However, the appropriate equipment and environment are necessary for cross-country skiing.

Jumping Rope

Jumping rope is a great way to maintain fitness on board a ship or in confined spaces. It can provide a high intensity, cardiorespiratory workout if done long enough and fast enough. If the pace is fast, it is equivalent to running in terms of energy expenditure.

Jumping rope does not have to be boring, especially if you use different types of jumps. Table 3-6 provides the names and an explanation for alternatives to the basic jump.

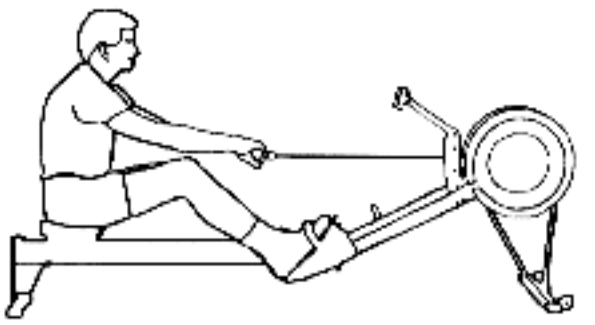
Table 3-6. Different Types of Jumps for Jumping Rope

Type of Jump	Description
Boxer's Dance	With both feet together, shift weight from right to left with each jump.
Run	Jump to the left while lifting left knee, then switch.
Shuffle	Start with right foot forward and left foot back, then switch each jump landing on both feet at same time.
Knee-Toe	Tap right toe on the floor, then jump from your left foot to your right; at the same time lifting left knee as high as possible. Switch legs.
Double Rotation	Twirl the rope around twice between each jump.
Jumping Jack	Jump two times with feet together, then do a jumping jack every third time.

In terms of gear, many different types of rope are available, and rope jumping can be limited by the quality of the rope. Most experts recommend lightweight leather ropes. Believe it or not, many books have been written about jumping rope, with basic to advanced skills, drills and moves. Overall, jumping rope is a great activity, especially if you are in a confined environment.

Stationary Exercise Alternatives

Rowing Ergometer



There are many types of rowing machines on the market, and each has distinct advantages and disadvantages. The best rowing machine is one with variable resistance and the ability to regulate rowing rate. Most provide feedback on either watts or kcalories per hour, as well as meters covered. Proper technique is critical so as not harm your lower back. If proper technique is maintained, cardiorespiratory conditioning can easily be achieved. In fact, both the upper and lower body are exercised, and it

promotes flexibility by emphasizing maximum joint range of motion, so it is a total body workout. It is also impact-free so it is a great alternative to running! Some key points to remember are:

- The motion of the entire stroke should be fluid.
- A stroke rate between 24 and 30 per minute should be the goal.
- Your grip should be loose and comfortable with wrists level.
- The rule of thumb should be a longer not a harder workout.

Just plain rowing can become a bit boring, but there are many ways to make it fun and varied. Table 3-7 presents descriptions of various workouts for a rowing ergometer.

Table 3-7. Various Workouts for a Rowing Machine

Workout	Description
Steady State	**20 to 40 minutes at a pace which barely allows you to chat with a partner**
Intervals	**3 to 5 sets of 300 to 500 meters at a fast pace with 2 minutes of rest between each set**
Fartleks	**Alternate 1 minute hard and 1 minute easy for 20 minutes**
Long and Slow	**6,000 meters at an easy pace**
Time Trial	**2,000 meters at a record pace**
Pyramids	**1 min hard, 1 min rest, 3 min hard, 2 min rest, 5 min hard, 3 min rest, 7 min hard, 5 min rest, 5 min hard, 3 min rest, 3 min hard, 2 min rest, 1 min hard**

How do you know if the workout is hard or light? Your body is the best judge, but knowing the kcal/hr will also help. A pace of 500 meters/4 minutes would be a light workout whereas a pace of 500/2 minutes would be strenuous. These paces equate to 385 and 970 kcal/hour for a 70 kg man.

Bicycle Ergometers

Cycle ergometers have been around a long time, and are still the mainstay in exercise/fitness testing. Monitors on the bicycles available today typically display kcal per hour. Table 3-8 presents kcal/hour values for stationary bicycle workouts at various intensities. These values can be used to gauge your work rate during indoor biking.

Table 3-8. Energy Expenditure (kcal/hr) for Stationary Cycling at Various Intensities and Body Weights

Body Weight (lbs)	Intensity			
	Light	Moderate	Vigorous	Strenuous
155	320	450	600	770
175	360	520	680	880
200	400	590	760	990
220	450	650	850	1100

Treadmills

Despite the fact that it is much nicer to run outside than inside, the treadmill is an extremely efficient way to maintain and/or improve cardiorespiratory conditioning. Unlike the cycle and rowing ergometer, jogging or running on a treadmill is weight dependent: the energy expended is determined by your body weight. In addition, it is an impact sport and should not be the only form of conditioning, so joints are protected and injuries minimized. However, if you are on a ship or in another type of confined space, a treadmill could maintain your fitness!

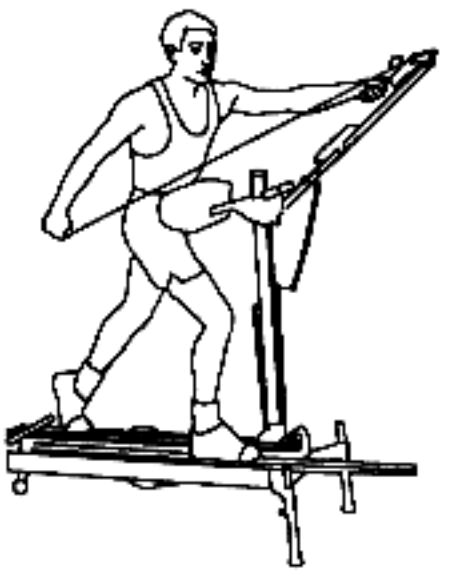
What kind of workouts should you do on a treadmill? Three days per week is more than enough, if you do other types of exercise on off days. On a treadmill, you can mix up your pace and/or change the resistance by changing the incline. The incline and speed will determine the intensity of the workout. Remember, a strenuous workout is over 750 kcal/hr, and a

moderate workout would be 450 to 600 kcal/hr. Table 3-9 presents kcal/hr values for treadmill workouts. These values can be used to determine the speeds and grades for indoor running.

Table 3-9. Approximate Energy Requirements (kcal/hr) for Horizontal and Uphill Running on a Treadmill

	Speed (mph)				
% Grade	4	5	6	7	8
0	425	515	610	700	800
2.5	470	570	670	775	880
5.0	510	620	740	850	970
7.5	550	670	800	920	1045
10.0	600	720	850	990	1125

Ski Machines



The simulated skiing machine provides an excellent mode of exercise for whole body conditioning. It uses both the upper and lower body, and offers a range of settings so your workout can be light, moderate, vigorous or exhausting. Maintaining a comfortable rhythm is most important during a moderate workout, and is essential for progressing to a strenuous workout. Importantly, unlike running outside or on a treadmill, minimal stress is placed on the joints. Most models have various settings for modulating leg resistance, and typically the resistance ranges from four to 32 lbs. Once you have determined your desired resistance the intensity of your workout will be determined by your average speed. Numerous tables are available which allow you to determine the number of calories expended per minute at various resistance settings and speeds. However, they are far too detailed to include here. Table 3-10 presents the kcal/hr expenditures for various settings and speeds for a 70 kg (155 lb) man. These values can be used as to estimate your actual work rate.

Table 3-10. Energy Expenditure (kcal/hr) on a Ski Machine at Various Settings and Speeds

Setting	Speed (kilometers per hour)					
	5	6	7	8	9	10
3	485	530	575	620	670	710
4	550	600	645	690	735	780
5	620	660	710	755	800	850
6	680	730	775	820	865	910
7	750	800	840	885	930	975
8	815	860	905	950	1000	1045

Some indoor skiing machines also have multiple settings for arm resistance, and adjustments to these settings should be made to ensure a moderate to vigorous workout. However, kcal/hr expenditure for arm settings becomes quite complicated and will not be presented here. All in all, ski machines provide great exercise, and would be extremely beneficial for SEALs involved in winter warfare training.

Stair Steppers

Stair steppers provide an excellent alternative to running, biking, and other forms of aerobic exercise. Although stair-stepping is a weight-bearing exercise, the impact is much less than with running. However, to get the full effect, instructions must be followed. Most people hang on to the handles and this diminishes the conditioning effect. An equally good workout could be gained by actually climbing real stairs for the same period of time; many people climb stairs without holding the handles, and thus carry their full weight up the steps. By hanging on, you allow your arms to support a portion of your body weight and the energy demands are less.

Most stair steppers have a variety of computerized, pre-designed programs to meet the needs of devoted users. There are interval training programs, climbing programs, manual programs, and many other creative exercise programs to vary the intensity of the exercise. Although each manufacturer has its own energy cost equations, the way to determine work intensity is to determine the number of steps per minute; one step is typically 8 inches of vertical climb. A low intensity exercise would be a step rate of

less than 35 steps/minute, whereas a high intensity workout would require a step rate in excess of 95. This is not an easy exercise routine. Table 3-11 presents the approximate energy expenditure in kcal/hr for a 155 lb SEAL at various stepping rates.

Table 3-11. Energy Expended (kcal/hr) during Stair Stepping at Various Step Rates

Step Rate in Steps/minute	35	60	95	120	140
Approximate kcal/hr	250	390	580	730	820

Climbers

Workouts on a climber will build upper body strength and provide excellent cardiovascular conditioning. Different types of climbers are available, and each has specific characteristics. Regardless of which variety is used, climbers have common features: weight dependent exercise that conditions primarily the upper body.

Energy expenditure on a climber depends on your speed of climbing and your body weight. Some authorities would say that climbing results in a greater energy expenditure than most other activities, but this depends on your strength and how hard you work. Table 3-12 provides kcal/hr at selected weights and ascent rates.

Table 3-12. Energy Expended (kcal/hr) on a Climber at Designated Weights and Feet per Minute

Weight in lbs	Feet Climbed Per Minute					
	40	60	80	100	120	140
140	360	480	600	690	810	930
160	420	520	670	800	930	1050
180	460	600	750	900	1050	1200
200	510	670	840	1020	1170	1320
220	570	750	930	1100	1270	1450

Basic Workouts

The most important issue with respect to workouts is recovery. Rest is an exceedingly important factor in recovery from strenuous workouts, so back-to-back high intensity workouts are not encouraged. Experts recommend a hard day followed by an easy day, and at least one day of rest over a seven day period. This can be an excellent plan, but you should also let your body be your guide. Some days when you go to workout and feel great, this day can and should be a hard workout day. On other days when it is an effort to even get your workout clothes on, this should either be a rest day or an easy day.

Easy days could be a run, bike, or swim at a very comfortable pace for 60 minutes or more, an easy short workout, or a short hump with a light load. A hard day may be intervals, fartleks, a fast pace for a specified period of time, a long hump with a heavy load, or a competition among team members. The key is to make it fun, challenging, and interesting.

Other Terms for Work Rate

Other terms are frequently used to describe exercise intensity and work rate. These include:

- Work
- Power
- METS
- Watts

If these terms and concepts are learned, they will apply to almost all exercise equipment and conditioning programs. The terms work and power are often used incorrectly. Because these terms can be expressed in a variety of ways, it is useful to understand or at least be familiar with the basic units of measurement.

Work and Power

Work = Force x Distance and is measured in kcal

Power = Rate of Doing Work and is measured in watts

METs and Watts

The term MET, which was used in the national recommendations for exercise, is often used to estimate energy expenditure and work rate.

A MET is defined as a multiple of resting metabolic rate or energy expenditure.

One MET is between 0.200 to 0.250 liters (of oxygen)/min, or approximately one kcal/min, depending on the weight and body type of the person. Two METS would be two times resting metabolic rate or approximately 0.5 liters (2 X 0.200 to 0.250) of oxygen/min, or 2 kcal/min. Likewise, 3 METS would be 0.75 liters (3 X 0.200 to 0.250) of oxygen/min, or around 3 kcal/min.

Watts, as stated above, are units used to quantify the rate of doing work, or work/time. Most new exercise equipment express work rate in terms of watts, although many use METS instead of or as well as watts. Table 3-13 presents the relationship between various terms denoting exercise intensity. These can be used to monitor exercise intensity.

Table 3-13. Workload Conversion Sheet

Watts	Oxygen Uptake (L/min)	Work Rate	Energy Output (kcal/hr)	METS
50	0.9	Easy	270	4.0
100	1.5	Fairly Easy	450	6.7
150	2.1	Moderate	630	9.3
200	2.8	Moderately Hard	840	12.4
250	3.5	Very Hard	1050	15.5
300	4.2	Very, Very Hard	1260	18.7

Summary

No doubt new modes of exercise will be appearing in the future. What you chose to use will depend on many factors. The important issue is whether you are able to achieve the desired work rate and conditioning level. A recent study of indoor exercise machines examined energy expenditure at given ratings of perceived exertion. They compared a treadmill, a rowing ergometer, a combination cycle/arm ergometer, a cycle ergometer, a stairstepper and a cross-country skiing simulator. Surprisingly they found that rates of energy expenditure varied by as much as 261 kcal/hour for the exercise machines when subjects exercised at self-selected work rates corresponding to fairly light, somewhat hard, and hard. The treadmill came out with the greatest energy expenditures, followed by the rowing and stairstepping ergometers; the cycle and combination cycle/arm ergometers came out with the lowest values. If exercise intensity is established by perceived effort, treadmill running/walking will result in greater energy expenditure and a stronger cardiorespiratory training stimulus for a given duration of exercise as compared to other modalities.

Chapter 4

Running for Fitness

Running is a fundamental part of your physical training program and provides an excellent aerobic workout. Moreover, it is not expensive; most of the cost of running involves buying a pair of "good" running shoes. If you train intelligently and have the right gear, you can continue to enjoy the fitness and general sense of well-being that accompanies running while avoiding running injuries. In this chapter, basic information is provided for maintaining a sound, middle distance running (20 to 40 miles/week) program; this is adequate for running 10K and half marathon races. Some of you may consider running a marathon in the future; at such a time you may want to get training tips from experienced marathoners, trainers at a running club or running magazines.

Running Gear

Running Shoes

A good pair of running shoes will provide shock absorption, cushioning, motion control and durability, and ultimately help prevent injuries. Under no circumstance should you buy shoes if they do not fit correctly. Running magazines usually have a yearly review of various running shoes, newest models of shoes and the type of runner the shoes are most suited to. You can also obtain current information from "Running Sites/Pages" on the worldwide web. It is wise to try on several different shoes at a sporting goods store to determine which one might be best for you. This is also important if you are planning to buy shoes from a catalog.

Pronation

It is important to understand this term because the type of running shoe you buy depends on whether you are a normal, over-, or under-pronator. While running, the outside of the heel strikes the ground first. Next, the foot rotates inward and downwards: this process is called pronation. Everyone pronates to some degree and pronation helps the foot absorb the shock of impact. However, some runners over-pronate: their feet roll too far inward. Put your running shoes together and look at their heels/backs; if they lean inward, you are probably over-pronating. Another way to check pronation is to have a friend run behind you and have them watch the back of your heel as it makes contact with the ground: the greater the inward roll of your heel, the more you pronate.

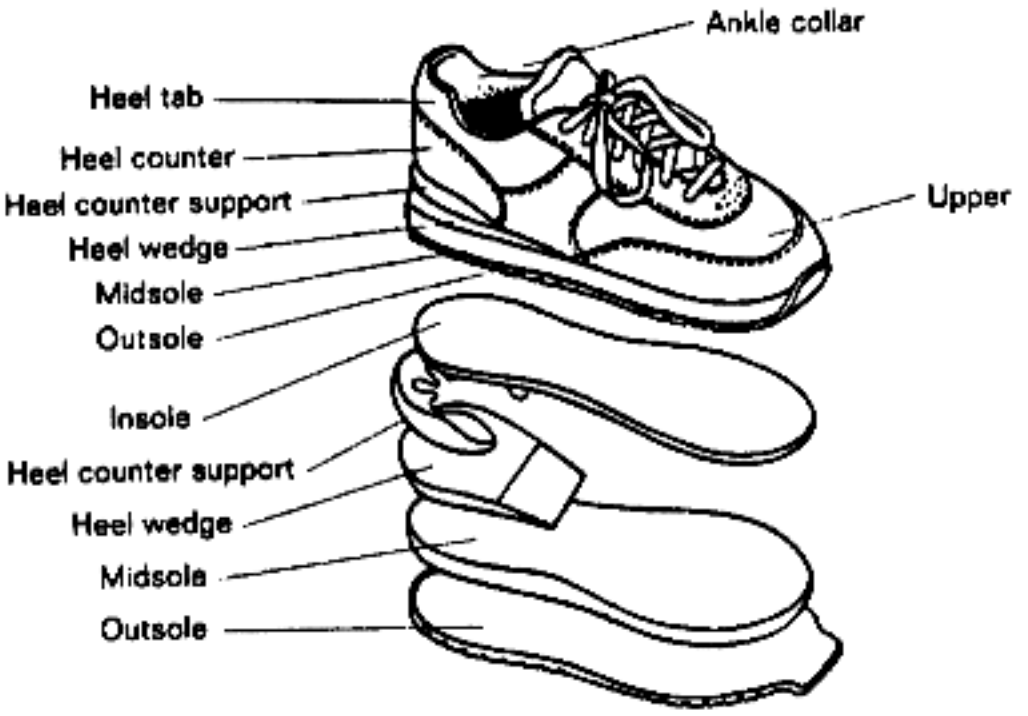
Excessive pronation can lead to injuries of the lower leg and knee.

Other runners under-pronate or their feet do not have enough inward roll after striking the surface. Such individuals are considered to have "rigid" feet or feet that absorb shock poorly. Shoes are available to correct for either under or over-pronation.

Shoe Terminology

When buying running shoes, it is helpful to be familiar with some common terms. Figure 4-1 presents the various parts of a running shoe.

Figure 4-1. Parts of a Running Shoe



Some General Terms

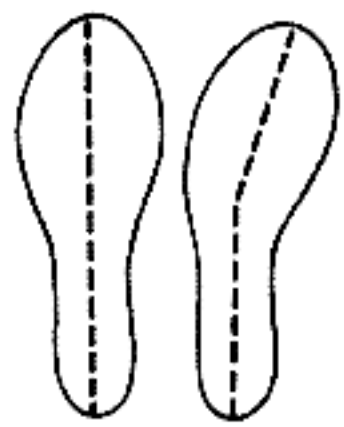
- **Outsole** is the material on the bottom of the shoe that comes in direct contract with the running surface.
- **Midsole** is the layer of cushioning that is placed between the upper and outsoles.
- **Lateral** is the outer-edge of the shoe.
- **Medial** is the inner or arch side of the shoe.
- **Upper** is the part of the sole that is above the midsole.
- **Achilles notch** is the U or V-shaped cut at the top of the heel collar which prevents irritation of the achilles tendon.
- **Heel counter** is a firm cup usually made of plastic that is encased in the upper and surrounds the heel to control excessive rear foot motion.
- **External heel counter** is a rigid plastic collar that wraps around the heel of the shoe to provide support and control excess pronation.
- **Motion control designs** or devices control the inward rolling or pronation of the foot. Some amount of pronation is normal: corrective measures are necessary only if there is excessive rolling or under-pronation.

Terms Related to Cushioning

- **Cushioning** is provided by midsoles and is needed for shock absorption.
- **Cantilever** is a concave outsole design in which the outer edges flare out during foot strike to provide better shock absorption.
- **EVA** is a foam-like material which is used in midsoles to provide cushioning.
- **Polyurethane (PU)** is a synthetic rubber that is used with EVA in midsoles. It is more durable than EVA but provides less cushioning. PU is used in the rear foot for firmness and EVA in the forefoot for flexibility and lightness in many shoe models.
- **Metatarsal pad** is a soft wedge of EVA that is placed under the ball of the foot to increase cushioning and shock absorption for runners who are fore-foot strikers.

Terms Related to Shape

- **Last** is a foot shaped piece of wood, plastic or metal which is used as a frame for building a shoe. Lasts can be straight or curved as shown in Figure 4-2.
- **Straight-lasted shoes** are relatively straight shaped on the inner or medial side and provide support and stability and are recommended for runners who over-pronate.
- **Curve-lasted shoes** are shaped to curve inwards (see figure). This shape allows greater foot motion and such shoes can be worn by runners with normal pronation and arches.



Straight Curve

Figure 4-2. Types of Lasts Used for Running Shoes

Terms Related to Shoe Construction

- **Board lasting** increases stability and is good for orthotics. A board-lasted shoe is made by gluing the upper to fiber board before it is attached to the midsole.
- **Slip lasting** is the most flexible shoe construction wherein the shoe upper is stitched together like a moccasin before it is glued to the midsole.
- **Combination lasting** as the term suggests is partly board and partly slip lasting. Such shoes are board lasted in the rear foot for stability and slip lasted in the fore-foot for greater flexibility. If you removed the sockliner you would see stitching in front and a fiber-board in the rear foot.

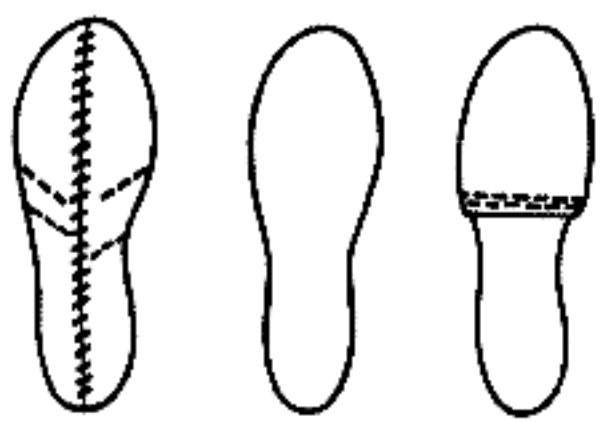


Figure 4-3. Shoe Construction: Lasting

Slip Board Combination

Pointers for Buying Running Shoes

- **Maximum emphasis on shock-absorbing characteristics.**
- **Know your foot type.**
- **Look for shoes that come in widths.**

Do you have normal arches, high arches or are you flat footed? You can assess your foot type by what is known as the "wet test": simply wet your feet and briefly stand on a piece of paper or on a dark, bare floor; look at the imprint left by your feet. Compare them to the impressions shown in Figure 4-4 to determine your foot type.

Figure 4-4. Types of Arches

If you have high arches you will need a shoe with more cushioning for shock absorption whereas if you are flat footed you will need a shoe with more support and heel control (see Table 4-1).

- **Know whether you over- or under-pronate.**

If you over-pronate you need shoes that provide stability, whereas, if you under-pronate you need shoes that provide shock absorption and cushioning.

- **Know if you are prone to running injuries.**

See a sports medicine doctor if you are predisposed to training/overuse injuries to determine if your injuries are related to biomechanics. Biomechanical conditions, such as being an over- or under-pronator, or having one leg shorter than the other, often result in running injuries. In some cases, you may benefit from using orthotics (see section on orthotics) in your running shoes. Also, take your running shoes with you when you go to see your doctor.

- **Try on shoes towards the end of the day.**

Feet are smallest first thing in the morning and swell slightly as the day progresses. Also, wear running or sports socks while trying on shoes since they are generally thicker than regular socks. Walk around the store in the shoes to check the fit, cushioning and stability of the shoe. If you use orthotics, lifts or other inserts, bring them with you when you try on shoes.

- **Do not buy shoes based on their brand name.**

Buy shoes that suit your biomechanical needs and work for your foot type, not shoes that a friend highly recommended or shoes you have seen a "good" runner wear. Consider going to a specialty shoe store where a knowledgeable salesperson can evaluate your running style and biomechanical needs, and recommend a shoe.

- **Replace worn out shoes in a timely manner.**

Wearing worn out shoes can eventually lead to injuries and cause knee or hip pain. It is a good idea to replace running shoes every 400 to 500 miles, or sooner if your shoes wear down quickly. One way to keep track of your running mileage is to establish a running log. A running log will not only help in keeping track of your running distance, but it will also help in tracking factors such as sudden increases in mileage or the onset of injury.

Table 4-1. The Right Shoe for Your Foot Type

Shoe Features	Flat Feet	Normal Feet	High-Arched Feet
Last - Shape	Straight	Semi-curved	Curved
Last - Construction	Combination	Combination	Slip
Midsole	Firm	Soft or firm	Soft
Motion Control	Yes	No	No
Orthotic Sole	May be needed to correct for over-pronation	No	No
External Heel Counter	Yes	No	Yes
Recommended Shoe Type	Motion control or stability shoes with firm mid-soles	Stability shoes with moderate control features such as two-density mid-sole	Cushioned shoes to provide lots of flexibility and promote foot motion
Avoid	Highly cushioned and curve-lasted shoes		Motion control or stability shoes

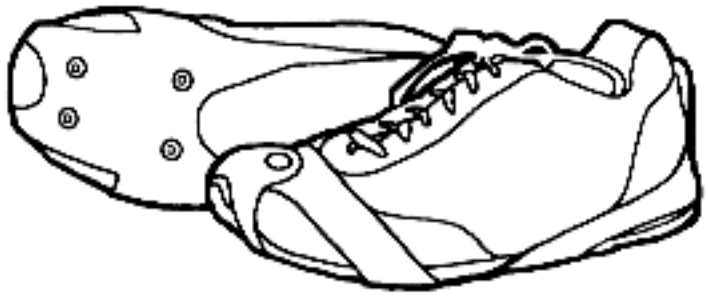
Orthotics

Individuals with biomechanical conditions that result in pain and injury may benefit from using orthotics in their running shoes. Orthotics are shoe inserts that are customized to an individual's biomechanics and foot type to provide good foot support and motion control. First, a plaster mold of the foot is made and then inserts are developed to correct the biomechanical problem(s). These inserts are usually made of cork soles covered by flexible leather or hard plastic. Orthotics should be gradually broken in; first wear them while walking and then progress to running. If not properly fitted, orthotics may worsen the problem. A podiatrist or sports medicine specialist is required to have them custom-made.

Sometimes low cost, over-the-counter, commercial orthotic inserts can work as well as customized inserts. For example, if the amount of pronation is not too much, over-the-counter inserts may correct the problem. Commercial inserts are sold by shoe size. If you find that the pain lessens, but does not go away or that the pain returns when you increase your mileage, you may need custom-made orthotics.

Cleats for Cold Weather Running

By putting on rubber cleats over a pair of running shoes you will be able to run outdoors under icy conditions. Personnel in the Arctic Warrior Brigade in Alaska use cleats when training in frigid weather. To obtain information about ordering these cleats, call Ft. Wainright (DSN 317-353-6048).



Clothes

Unlike many sports, running is not seasonal and with the right clothes, it is possible to continue to train outdoors on very hot or very cold days (see Chapter 11: Special Considerations for Training to review training under adverse environmental conditions). When weather conditions are extreme, as in ice storms, blizzards or a major heat wave, outdoor training can be substituted with running on a treadmill in the gym. Thus, running clothes can range from a simple pair of running shorts and a singlet to running tights and gortex jackets, depending on environmental temperatures. Cold weather running requires dressing in layers. Always keep your head and extremities warm in cold weather. Experience will teach you what to wear when running in the cold. If you wear too much, you may get hot after warming up, i.e., within the first mile or so.

Running socks tend to cost a bit more, but they are thicker and provide more cushioning than average sports socks. In most cases, sports socks are recommended as they provide adequate cushioning.

Other Gear Items

Heart Rate Monitors

You may have seen these advertised in running and fitness magazines. Some athletes use these for monitoring their training intensities. Such monitors consist of a wrist watch and a chest strap: the chest strap has an electrode which picks up your heart beat and transmits it to the watch which in turn displays your heart rate in beats per minute. If you know your target

training zone (see Chapter 1) you can check and maintain your heart rate within that zone. Heart rate monitors are not a training necessity and can be expensive.

Reflectors

Putting reflectors on your shoes and running clothes is a great idea if you routinely run late in the evening, at night, or very early in the morning when visibility is particularly poor. This is especially important in urban areas where motorists may not be paying particular attention to runners. Note that you should also run against the traffic.

Fluid Containers that Strap onto Belts

As you already know, it is very important to maintain fluid balance and prevent dehydration. Thus, if your long runs include running for more than 90 minutes, especially in hot weather, it is advisable to strap on a fluid container and drink fluid (8 oz.) at 30 minute intervals (refer to *The Navy SEAL Nutrition Guide*). If your running route provides access to water fountains then you need not carry your own fluid supply.

Portable Radio/Cassette Player/Walkman

Running with headphones can really help during long runs. However, it is not advisable to wear headphones and run on city streets as it may reduce your awareness of your surroundings. Running with headphones on base may be prohibited.

Running Surfaces

The ideal running surface is flat, firm, smooth and provides some shock absorption. Surfaces in the order of most to least desirable are listed in Table 4-2.

Table 4-2. Running Surfaces: From Best to Worst

Surface	Comment	Rating
Soft, smooth cinder track, unbanked	**Least likely of all to aggravate biomechanical injuries. Change direction frequently on any track to reduce mechanical problems.**	**1- Best**
Artificially surfaced track, unbanked	**Provides less shock absorption than the cinder track.**	**2**

Table 4-2. Running Surfaces: From Best to Worst

Surface	Comment	Rating
Soft, smooth dirt trail	Provides reasonable cushioning and holes and ruts are clearly visible.	3
Flat, smooth grass	Grassy areas including golf courses make relatively poor running surfaces since they hide uneven areas.	4
Asphalt street or path	Poor surfaces since typically sloped to facilitate rain water run-off. Surface slant causes one foot to pronate more and other to supinate more. Biomechanical problems are aggravated especially if runner tends to run in the same direction each time. Changing directions is highly recommended.	5
Hard, dirt track or trail	Watch out for ruts, holes, loose stones.	6
Concrete sidewalk or road	A very hard surface: wear good shock absorbing shoes.	7
Banked or cambered surface	Severe incline puts stress on the knees.	8
Hard-sand or soft sand beach	Beaches are slanted and can aggravate biomechanical problems. Do not run barefoot.	9
Rough, pot-holed, dirt trail or grass	A particularly hazardous surface. An unexpected hole or rut can result in ankle sprains.	10 - worst

Source: *Running Injury-Free* by Joe Ellis with Joe Henderson, Rodale Press, 1994

Other running surfaces include treadmills and water. Treadmills are very popular at fitness centers and may also be available to you when deployed aboard a ship. Most treadmills are state of the art in terms of cushioning and you can control the speed and intensity of your work out. Perhaps the biggest problem when working out on a treadmill is the boredom that is often associated with the monotony of the unchanging environment and the consistent pace. A portable cassette player or radio may be helpful, particularly during longer runs.

Deep water or aqua running is mainly used for rehabilitating injured athletes as it takes the pressure off of injured muscles and joints while providing cardiovascular benefits similar to those obtained with running on surface. This type of running is becoming popular at various swim centers.

Warm-Up

A warm-up to lengthen short, tight muscles before running is crucial for preventing injuries that may result if muscles are "cold". A longer muscle is less likely to get injured than a short, tight muscle because it can exert more force with less effort than a short muscle. Another benefit of warming up is that it protects tendons. Warm up by slow jogging or walking for five to 10 minutes before you run. **After you warm up you need to stretch your hamstrings, quadriceps, hip flexors, groin, calves, achilles, and the iliotibial band**. Exercises to accomplish these stretches are provided in the chapters on "Flexibility" and "Calisthenics" and are included in your recommended PT (Chapter 15).

Cool-Down and Stretching

After completing your run, walk for a few minutes to cool-down. It is not a good idea to sprint at the end of your run and then come to a complete stop; this practice may result in an injury. Cooling down helps to shift the blood flow from the muscles to the heart and other vital organs. A cool down lets your heart rate slow down and your body gradually return to its pre-exercise physiological state. **Cooling down properly and stretching (see Chapter 7: Flexibility) after your run will go a long way towards preventing injuries.**

Running Gait or Form

Different runners may have different running styles. Running is a function of footstrike, forward stride, body angle, and arm drive. The key is:

Run naturally and remain relaxed.

Footstrike

For most runners, other than sprinters or very fast runners, the heel-ball footstrike method works well: (1) the outside of the heel strikes the surface; (2) the foot rolls inwards to the ball of the foot while the knee is slightly bent; and (3) the foot lifts off from propulsion provided by the big toe. This method provides good shock absorption.

Forward Stride

The point of foot contact should occur in line with the knee which should be slightly flexed. As you improve and get faster, the length and frequency of your strides will increase and you will begin lifting your knees higher. Do not overstride such that your foot hits the ground ahead of the knee flex (i.e. leg should not be straight at point of impact). Overstriding is hard on the knees, back and the hips and can cause injuries. Short, choppy strides, which usually result from tight or inflexible muscles, require more energy and are inefficient. Run with a relaxed stride and do not exaggerate the knee-lift or back kick.

Body Angle

Keep your back as straight as naturally possible, your head up and look ahead. Of course, depending on the terrain you may have to look down to avoid tripping or landing in a hole or rut. Lean forward only when going uphill or sprinting as this motion will put stress on leg muscles and may cause back pain and shin splints. Leaning back is not recommended as this puts tremendous pressure on the back and legs and has a "braking effect". The key is to run "tall" and remain relaxed; allow your shoulders to hang in a relaxed manner and let your arms drop from time to time.

Arm Drive

While running relax your shoulders, elbows, wrists and fists and occasionally let your arms hang down at your sides and loosely shake them out. Whereas vigorous pumping of the arms helps sprinters, it is unnecessary during distance running.

Building Your Mileage

Increasing mileage too quickly can cause training injuries. Your running mileage should be gradually increased and not by more than 10% to 20% from one week to the next. For example, if you can comfortably run four miles, increase your distance by a mile and maintain this new mileage for at least one to two weeks or until this distance is consistently easy for you. Also, remember consistency is more important than speed.

A good rule of thumb: increase your mileage by no more than 20% a week.

When you can continuously run for 40 minutes, begin thinking about your running mileage or distance. Most of you, unless coming back from an injury or returning from a deployment, are already running 30 to 40 minutes as part of your fitness routine. However, if you have been unable to run for some time due to reasons mentioned above or other reasons, start out slowly; this will prevent you from getting injured and benefit you in the long run.

Running Frequency

Run at least three to four times per week or every other day. It is a good idea to build in one or two rest days in your weekly running schedule. These rest days do not necessarily mean no exercise, but rather an alternate type of exercise, such as biking or swimming. This allows your "running muscles" time for rest and recovery, and helps prevent overuse training injuries.

Running Speed and Intensity

When running for exercise and not competition, you should run at an even pace that allows you to talk comfortably. If you run too fast and get breathless, you may not be able to go the distance. Also, speed work tends to tighten muscles and must be properly stretched afterwards. Failure to stretch may lead to an injury. One way to estimate your training intensity is to check your heart rate and see if it falls within your target training zone (See Chapter 1). As previously mentioned, speed is not as important as being able to go the distance consistently. Figure 4-5 presents tips on how to increase your running speed.

Figure 4-5. Ways to Increase Running Speed

Increase length of stride: do not overstride

Increase frequency of stride

Increase length and frequency of stride

Do not increase speed and distance simultaneously.

Increasing both at the same time may cause an injury. Hold one constant while you gradually increase the other. After you have been running 30 minutes continuously 3 - 5 times per week, you can begin increasing your running distance. Running 20 to 30 miles per week is a good training distance for an intermediate runner. If you would like to further increase your weekly mileage, remember to increase it by no more than 20% per week. Table 4-3 provides a nine week program for running up to 40 miles per week.

Table 4-3. A Program to Run 40 Miles per Week

Week	Mon	Tues	Wed	Thur	Fri	Sat	Sun	Total
One	4	CT*	5	3	CT	3	5	20
Three	5	CT	5	5	CT	5	5	24
Five	5	CT	6	6	CT	6	6	29
Seven	7	CT	7	8	CT	5	8	35
Nine	6	CT	8	8	CT	8	10	40

*CT=Cross train on these days.

The program in Table 4-3 provides a basic template for you. Based on your own routine, you could modify this program to fit your schedule and requirements. Another way to vary your workout is to have one long slow run and one fast run per week. Remember if you feel over tired, cut back your mileage or take a day off from running. With a running base of 40 miles per week you can easily run a half marathon.

Training for a Marathon

If you have been running 35 to 40 miles per week for 1 to 2 months, you have a good endurance base for running a marathon after 3 additional months (12 weeks) of training (Table 4-4). To run a marathon, you must complete some long training runs in the weeks leading up to the marathon. The week that you run the marathon, however, should include only a few short runs. Your goal for your first marathon should be to complete it.

Table 4-4. A 12 Week Marathon Training Program Starting at 40 Miles/Week

Week	Mon	Tues	Wed	Thur	Fri	Sat	Sun	Total
One	-	5	8	5	5	4	15	42
Two	-	8	5	10	5	5	12	45
Three	-	6	8	6	6	4	15	45
Four	-	8	8	10	5	5	14	50
Five	-	6	8	8	6	4	18	50
Six	-	6	10	12	5	8	14	55
Seven	-	5	10	10	6	4	20	55
Eight	-	8	10	10	10	8	14	60
Nine	-	8	10	10	6	6	20	60
Ten	-	8	4	10	10	8	15	55
Eleven	-	5	10	10	5	4	18	55
Twelve	-	8	6	4	-	2	Marathon	

Other Points to Consider

- Make sure you eat enough carbohydrates and are well hydrated before the marathon. Refer to *The Navy SEAL Nutrition Guide* for information about high carbohydrate diets and fluid replacement beverages.
- Start out slowly and pace yourself.

- Walk for a while if you get cramps or feel fatigued.
- Consider the environmental temperature; if it is a hot and humid day, it is especially important to pay attention to your fluid and electrolyte needs (Refer to Chapter 11 and to *The Navy SEAL Nutrition Guide).*
- After you finish, stretch and walk around. Take a hot bath.
- Slowly return to running.

Interval Training

Various interval training techniques can be used for building speed. Ideally, speed work would be done on a measured track. Sample interval training workouts are provided in Figure 4-6. Two important points are:

- Rest periods between reps for intervals to train the anaerobic energy systems should be equal or slightly less than time to cover distance (quarter mile: 60 seconds; rest: 60 seconds)
- Rest periods to train aerobic system should be less than one-half time to cover distance (half-mile: 2:50; rest: 60 seconds)

Figure 4-6. Sample Sprint and Distance Running Interval Workouts

Sprint

One mile warm-up, slow pace

10 minutes lower body stretching

Quarter mile sprint w/ 60 to 90 second jogs: Repeat five times

Half mile sprints/ 2 to 3 minutes jogs: Repeat three times

One mile cool-down, easy pace

Whole body stretching

Distance

One mile warm-up, slow pace

10 minutes lower body stretching

One mile sprints/ 1 to 2 minute jogs: Repeat four times

Two mile cool-down, easy pace

Whole body stretching

These are not the only interval workouts, so you may modify them to suit your requirements. For example, you could do pyramids: you would start with a quarter mile, followed by a half mile, 3/4 mile, and mile, then go back down in reverse. Between each speed set, it is best to jog one quarter to one half the distance to accelerate recovery.

Interval workouts are a great way to improve performance.

Varying Your Workouts

It is good idea to vary your daily running mileage so you have some "light" days in between heavy training. Avoid running long distances on two consecutive days, unless you are training for a marathon, to give your body time to recover. Listen to your body and pace yourself accordingly.

Most importantly, it is good to cross-train.

Consider biking, swimming, stair-climbing or other activities that will provide a good aerobic workout while mainly using muscles other than those used during running. A major benefit of cross training is that it prevents the onset of over-use injuries while maintaining fitness. For information about cross-training see Chapter 3: Cardiorespiratory Conditioning. Strength training, especially upper body strength workouts, have become an important part of a "runner's" overall workout. It is recommended that you strength train two to three times a week (see Chapter 6).

Common Running Injuries or Problems

Most running injuries are due to "over use" from running too much, i.e. too fast, too far, or too often. See Chapter 12: Training and Sports Related Injuries for more information about injuries. The following table shows the incidence of various running injuries that were reported by male runners in a recent survey (Adapted from *Running Injury-Free* By Joe Ellis with Joe Henderson, Rodale Press, 1994).

Table 4-5. Frequency of Running Injuries Reported by a Sample of Male Runners

Injury	Frequency (%)
Knee	23
Achilles Tendon/Calf	16
Metatarsal	11
Hip/Groin/Toenails/Blisters	9
Plantar Fascia/Heel	8
Ankle Sprain	7
Shin Splints	6
Nerve/Quadriceps/Hamstring/Back	2

If you train sensibly there is no reason why you should not be able run injury-free. Should you get injured, information on how to go about seeking treatment for training related injuries is provided in Chapter 12. Keep in mind the three principles of a good running form as shown in Table 4-6.

Table 4-6. Three "Principles" of Good Running Form

Run Tall
Run Relaxed
Run Naturally

Resources

- Joe Ellis with Joe Henderson, *Running Injury-Free*, Rodale Press, 1994.
- Bob Glover and Jack Shepard, *The Runner's Handbook*, Penguin Books, 1985.

Chapter 5
Swimming for Fitness

As a SEAL you are required to be a swimmer.

Swimming is an excellent exercise for overall fitness; aerobic endurance, power, strength, and flexibility are all enhanced by swim training. It is generally gentle on the joints and provides excellent cross training for running and other gravity-intensive forms of exercise by providing load-bearing joint rest. However, training must be specific for the anticipated operational environment, including cold water acclimatization. This section will give you the tools to improve your swimming skills, thus enhancing your fitness for combat swimmer missions.

You must primarily train for endurance while preserving the significant power and strength required by other phases of SEAL operations. This section includes information on competitive swimming strokes and pool training, but it is important to emphasize that most training for SEAL combat swimmer operations should consist of open water swims with fins. Open water training is essential for SEALs as a part of a comprehensive training program under the general principle of "specificity of training". Surf and high sea state swimming provides specific training for potential operational situations by increasing your sense of timing and confidence.

Swim training should focus primarily on open water swims with fins.

Swim training is best accomplished with others for a variety of safety reasons. There should always be a guard or buddy available to you, even if you swim in a pool. You certainly should not train alone in open water.

Open Water Gear

In the pure sense the only gear required is a set of trunks. Look at the gear list for the UDT swimmers at Omaha Beach in 1944. It did not even include fins and masks. However, today there are some significant gear issues. Goggles are necessary for any real swim training. Operational and open water swimming requires more gear. There are specific training aids that help develop strength and technique in pool training. Swimming is still an inexpensive sport with respect to gear; a complete set of the most expensive training gear for pool training will not cost over $100.

Wet Suits

Open water swimming may require thermal protection for safety. Males in particular may be susceptible to hypothermia and the first symptom in an open water swimmer may be unconsciousness from cardiac arrhythmia. Thermal protection in swimmers means a wet suit worn over an anti-chafing shirt.

Wet suits designed for open water swimming are generally of a Farmer John design with the arms free for stroking. In all but the coldest water, a 1/8" wet suit is best for surface swimming. Unlike diving, there is no need to factor in the loss of insulation due to compression of the neoprene with depth. However, this is not true for the combat swimmer operations that may entail prolonged periods in the water.

Anti-chafing shirts are generally made of nylon without elastic properties. Worn under the wet suit, the nylon shirt allows arm strokes and head rotation without getting chafing from the wet suit. If you don't use anti-chafe shirts, then this would not matter.

Hood, Gloves and Booties

- Good open water swimming hoods allow the head to be turned with minimal chafing. Thermal protection is not as good with the neck exposed. A good hood preserves a great deal of the swimmer's heat.
- Gloves may have webbed fingers to allow sidestroke pulling to be more efficient. They work great for freestyle, too. Neoprene web gloves are popular and work like paddles.

- Thin 1/8" booties without soles maximize the power delivered by the swimmer's legs to the fins.

Fins and Fin Selection

There are three factors to keep in mind when you are selecting a fin; the specific design characteristics of the fin, the physical attributes particular to your body, and operational constraints. Fins, by increasing the surface area of the foot, serve to magnify the thrust delivered by the legs. Kicking with fins involves a forward stroke and a backward stroke. Several examples will illustrate how the three factors interact to influence the SEAL's fin selection.

- SDV operations require an operator to sit with fins on for a long period of time. The operator may require thermal protection and he may have a flexible ankle. Space is limited, so a shorter fin is necessary. For this situation, the operator should select a short, wide fin with a strap that can be adjusted for varying amounts of thermal wear.

- Surface swimming with gear will involve a sidestroke flutterkick. In the sidestroke, forward is toward the front of the swimmer's body and backward is toward the swimmer's back. Applied force is typically much greater during the forward stroke, and fins are often designed with this fact in mind. When power is needed for both forward and backward kick, like in sidestroke, a straight symmetrical fin may be more efficient for you.

- Underwater swimming involves a face down position, where the forward stroke is down and the backward stroke is up towards the surface of the water. In this position, gravity assists with the downstroke and produces a less symmetrical type of thrust than seen with sidestroke kick. You should select a high-tech diving fin with moderate flexibility and an integral type footbox. The fin should have an offset design to allow a more efficient transfer of propulsion force.

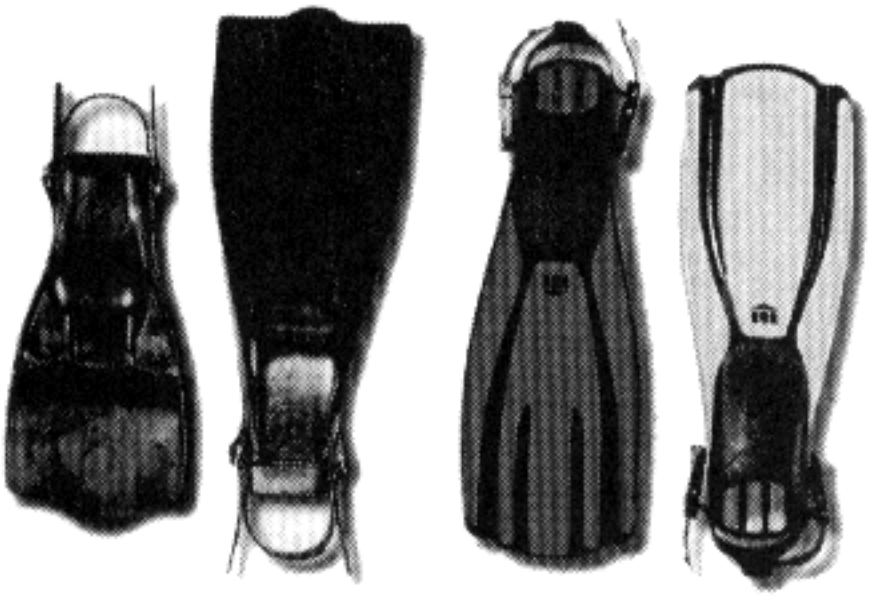
- For bodysurfing, use short surf fins.

The main principle of fins is to increase the surface area of the foot.

Table 5-1. Recommended Fin Types

Type of Swimming	Type of Fin
SDV Operation	Short fin (Beware of compromised propulsion power. Rocket fin is wide and may provide extra safety factor).
Underwater Swimming	Offset fin
Surface Swimming	Straight fin

Figure 5-1. Examples of Traditional Short and Long Fins (Left) and Newer Long Blade Fins with Innovative Buckles (Right)



Specific Design Characteristics of Fins:

- Size or surface area of fin blade
- Stiffness of fin blade
- Configuration or shape of fin blade - length and width
- Integral footbox versus strap-type fin
- "Offset" or angle of pitch between footbox and fin blade
- Buoyancy of fin

Physical Attributes Influencing Fin Selection:

- If your ankle range of motion is inherently limited, long fins will assist in transmitting lower extremity forces to the water.

- If your ankles are inherently flexible, short fins may be more efficient as well as less stressful on relaxed ankle joints.
- Your natural kick frequency will also influence your choice of fin stiffness and size. Larger sizes and stiffness produces a slower rate of kicking, while short flexible fins allow a higher kick rate.

Operational Constraints:

- Face down versus sidestroke position
- Surface versus submerged
- Space limitations (SDV)
- Thermal protection

The fit of the fin is critical.

If the fin is too tight, the finbox may make your foot cramp up and more susceptible to cold. If it is too loose, energy is lost in the slop between foot and footbox; slop also translates into foot chafe! Booties provide grip for the foot within the footbox and the neoprene acts to even out areas where stress is concentrated.

Other Fin Selection Considerations

Fins vary slightly in buoyancy; about half of sport fin models float and the remainder sink. This may be an operational consideration. In the April 1996 Rodale's Scuba Diving fin test, fins testing as "outstanding" in the area of power included the expensive Scubapro Gorilla, Mares/Plana Avanti, Ocean Edge Spectra, and the U.S. Divers Blades. However, so did the IDI Frog Foot and Power Fin models, which have been the standard fins in the Teams for many years.

The authors of the article reveal honestly that, "In spite of extensive research and a multiplicity of designs applied to modern fins, there are still tried and true fins that perform as well as many of the top newer models." The older, buckle-style strap fasteners have the advantage of being reversible and are far less likely to foul in fishing line or seaweed than fasteners on newer models, many of which have quick-release buckles. The simple straps on older models have no plastic to break, are easy and inexpensive to replace, and can be found in almost any dive store. These fins are also not as slippery on deck as newer designs.

As a SEAL, you will need to evaluate individual fin performance carefully. You should not only consider characteristics of the fin, but know your own physical attributes and any particular operational constraints in making your decision.

When buying fins consider:

- Size, stiffness, weight, buoyancy, buckles and releases.
- Getting the best possible fit; try on fins with booties or other foot gear that you'll be using with the fins.

Face Masks

A face-mask is required for swimming as prolonged exposure to salt water and/or stinging marine organisms may cause eye irritation or injury.

For open water swimming, you should use your face masks.

Open Water Training

There is no substitute for ocean or lake swimming. Training in open water will force you to swim straight and develop a cycle of breathing that allows you to look forward in order to navigate. This is an essential skill for operational swimming. Group swims in open water are an excellent way to maintain fitness and should be used extensively in SEAL training programs. Open water training will maximize the training effect of using fins.

For operational open water swimming, the sidestroke with a flutterkick is superior to freestyle.

In rough open water and under operational circumstances you may want to combine a scissor kick with a sidestroke pulling technique to maximize your navigational ability and watch for breaking waves. However, sculling is as important in the sidestroke as it is in freestyle. Both arms should be used to incorporate sculling motions and to stabilize the swimmer's

trunk while the kick provides the main thrust. There are stroke efficiency issues with the sidestroke just as there are in other swimming strokes. Stroke coaching is invaluable in developing good technique.

Water Temperature Issues

Cold water is an issue to be addressed by SEALs training in open water. Although the work of swimming generates heat, there is heat loss created by movement of the swimmer into new "unheated" cold water. Thus, open water swimming may require various combinations of passive thermal protective gear, in particular, wet suits. The three determinants for passive thermal protection are:

- Temperature
- Length of the swim
- Effort level

It is important to remember that wet suits operate by allowing the body heat to be transferred to a layer of water caught between the body and the neoprene material of the suit. Convective heat loss from the swimmer's body is greatly reduced by this mechanism and as a result, swimming at a high effort while wearing a wet suit allows the swimmer to generate and retain heat. Guidelines have been developed for training and are presented in this section.

Research has established some known "bench mark" facts about operating in a cold water environment. In very cold water (below 40° F), the unprotected swimmer loses heat faster than an immobile person immersed in the same cold water. Heat generation simply does not keep up with losses. The immobile person warms the cold water immediately around his body thereby limiting total heat loss. However, in moderately cold water (around 68° F), an elite class swimmer may stay active, and the heat generated by swimming keeps pace with overall losses (although the swimmer may develop cold feet and hands). In this situation, the active swimmer outperforms the immobile person with respect to maintenance of core body temperature. Currently we do not know the crossover temperature point or the water temperature at which it is better to remain stationary than active in the water for thermal balance.

Passive thermal protection modifies this balance by reducing the convective component of heat loss. As a result, a swimmer may extend training durations beyond those possible without passive thermal protection.

Diving medicine specialists at BUDS have developed guidelines for use of passive thermal protection during training in cold water environments. Note that Table 5-2 is limited to high energy swims at a set distance of 2 miles.

Table 5-2. Distance, Temperature, and Protection Requirements

Swim	Water Temperature (°F)	Protection
Swim of 2 miles	> 64°	None
	63 - 64°	Hood Only
	60 - 62°	Wet-Suit Top/Hood
	50 - 60°	Full Wet Suit/Hood

Special Open Water Training Issues

It is easy to have chafing from the wet suit around the arms and also for the fins to chafe. Get thin booties without soles for fin use and consider using some vaseline or aquaphor ointment for other chafe points.

If you swim regularly in cold water, your body will undergo some adaptive changes. This will increase your tolerance to some extent. You will also begin to actually crave fatty foods, an instinctual tendency of cold water swimmers to want extra body fat to protect them! This is a natural adaptation, but this may be undesirable for your running and overall fitness.

Surf training is great for honing your aquatic skills and for developing confidence in big water. For body-surfing, use a medium fin, like short surfing fins, that permits quick acceleration but is small enough not to get caught in moving parts of the wave. Use velcro-elastic "keepers" for your fins unless you are sponsored by a fin manufacturer!

Keep your head down and always surf with an arm extended up over your head.

It is far better if you get folded by a big chopping wave to have your shoulder dislocated than for you to become quadriplegic from a cervical spine injury. Avoid shorebreaks; the waves are unpredictable and going over the falls may yield a screaming descent straight onto the beach sand. Instead try to find a good "grab and release" break where the wave stands up nicely and then breaks back into deeper water.

Another open water issue you may be faced with is that of sharks. They commonly attack solitary swimmers, particularly freestylers: the solitary, beefy organism making arm slaps against the surface of the water. Avoid swimming in places where you may resemble part of the food chain, but even then there appears to be protection in numbers. A good example is La Jolla Cove near San Diego. Here triathletes swim and Great White sharks eat small mammals all in the same day. Avoid swimming in the evening and get out of the ocean if you get bloodied too much in the surf.

Sharks virtually never attack swimmers in groups.

Swimming Pool Gear

Goggles

The most important gear for pool training is a good set of goggles. Get goggles that can be adjusted across the bridge of the nose. The fog-free goggles work better than they used to, but they do lose this quality relatively quickly under hard use and are much more expensive.

Kickboard

A kickboard is essential. They come in a wide variety of sizes and shapes, but all do basically the same thing.

Pullbuoy

A cheap, but essential, piece of training gear, the pullbuoy fits between the swimmer's legs for specific types of swim drills.

Hand Paddles

These are useful to develop the feel of sculling during freestyle pulling.

Zoomers

A unique and expensive short fin, the Zoomer is helpful but not essential. This special fin is designed to allow the swimmer to use flip turns during pool training sessions with minimal interference with technique. Other short fins may be substituted, notably the short, surf fins.

Nose Clips

Many individuals develop low grade nasal reaction to pool water. Use of a nose clip will allow a swimmer to complete some of the backstroke drills presented in this chapter much more comfortably.

Pool Training: Building Strength and Endurance

The major reason to use a pool is the quality of training. Swim sessions may be closely monitored and are safe. Controlled interval workouts used in pool training sessions provide good feedback; the pace clock doesn't lie. Pool sessions allow you to design workouts that vary in intensity and emphasis, which is not possible in open water. Pool training and acquisition of improved stroke skills are elective elements of a SEAL's training program. Pool training will increase your comfort level in open water, thus enabling you to significantly improve your operational capabilities.

Swimming is not an intuitive activity like running.

Warming Up

Warming-up should consist of at least 400 meters of swimming, along with some kicking and pulling drills. Warming-up is essential for swimming to avoid developing problems of the shoulder joint and upper back.

Target heart rate during warm-up should be about 60% of maximal.

During your warm-up, work on efficient stroke "stealth" swimming! Warming-up is an appropriate time to include stroke drills. This serves the purpose of providing stroke patterning along with the warm-up.

Basic Principles of Interval Training

SEALs need to concentrate on swim training that will enhance endurance: interval swim training will allow this to happen. Interval training sets (for both strength and endurance) are generally comprised of repeated swims lasting 45 seconds to 4 minutes. Basics of interval training include the following:

- Swim at a slow to moderate pace for five to ten minutes to warm-up muscles and cardiorespiratory system.
- For anaerobic training, sets should be performed until repeat times can no longer be held. There is no magical number of repetitions for a set, but the distance is typically 50 to 100 meters, or a time of about 45 seconds.
- Swimming at a prescribed intensity pace for as long as possible is most important. When desired pace can no longer be sustained, the set should be terminated.
- Work:recovery ratios play an important part in the type of adaptation that occurs. A 1:1 work:recovery ratio would be to swim 45 seconds and rest 45 seconds, whereas a 1:2 ratio would be to swim 45 seconds and rest 90 seconds.
- To stimulate endurance adaptations, recovery intervals between repetitions should be less than 30 seconds. For maximum benefit, it is best to keep the interval less than 15 seconds.

- For anaerobic adaptations to occur, recovery intervals should be in excess of one minute and up to at least twice the duration of the repetition swim. These effects occur independent of the repetition distance or pace.

- The longer the rest interval, irrespective of the distance being repeated, the greater the use of the anaerobic system. With long rests, it takes considerably longer for the aerobic energy system to be reactivated. Short rest intervals keep the aerobic system functioning, particularly during initial recovery.

Interval training is the backbone of a swimming workout.

Figure 5-2 illustrates how the different energy systems can be trained in an interval workout. Swim 1 is a hard effort, short distance and a lot of rest; this type of effort builds the anaerobic (CP) and transitional (Lactate-CP) energy systems. The second swim consists of fewer sets at a longer distance and with shorter rest intervals; this swim would challenge the aerobic system.

Figure 5-2. Energy Systems Used During Interval Sets

Lactate-CP System

Swim 1: 10 X 100 m with 45 sec. rest

10 = Repetitions (Sets)

100 m = Distance in Meters

Aerobic System

Swim 2: 5 X 200 m with 5 sec. rest

5 = Repetitions (Sets)

200 m = Distance in Meters

A swimming pace clock is the best way to time intervals: a diving watch works fine.

Interval Sets - Endurance

Freestyle Swim: 10 x 50 m with only 5 sec. rest

- Rest 5 seconds between each swim.
- Start with efficient "stealth" stroke, work into distance race pace. Don't overkick.
- Try to match your 1000 meter pace with this set.

Freestyle Swim: 50-50-100 m with 5 sec. rest

- Swim 2 x 50 meters with 5 seconds rest, then swim 100 meters: Repeat 3X.
- This set builds into a 100 meter swim where the swimmer tries to match the pace set in the 50 meters.
- Back off of the 50 meters a little to save up for the 100 meters.
- If you want, add an extra 15 seconds of rest between each 50-50-100 to keep the quality up.
- A "buildup" set like this will do great things for your endurance and sense of pace.

Freestyle Swim: 10 x 100 m with 10 sec. rest

- Rest 10 seconds between each 100 meter swim.
- Swim smoothly and efficiently. This is the set where you may exceed your long, slow swimming 1000 meter time!

Breaststroke Swim: 50-50-100 m - 5 sec. rest

- Done like the freestyle 50-50-100 set outlined above.
- Concentrate on keeping effort level up.

Interval Sets - Strength and Power

Freestyle Swim: 10 x 50 m with 30 sec. rest

- Begin at a strong pace. Build to race pace with a strong turn and an extra strong finish. Try to be within 5 seconds of your race 50 meters pace, usually equal to your race 200 meter pace.
- At first, try just 5 x 50 meters with 30 second rest.
- This is the most power-oriented freestyle set. It will also allow you to discover your true maximal heart rate. If you start to die off at the end, increase your rest a little to keep your pace.
- If you are particularly strong and want to build more speed, do this set with zoomers.

Freestyle Swim: 10 x 100 m with 45 sec. rest

- Same pace approach as the 50 meter interval set. This is for advanced swimmers with a refined stroke. It will build power, but this set should be used no more than once every two weeks.
- The rest interval should be 45 seconds for this length of swim; adjust your interval accordingly.

Breaststroke Swim: 10 x 50 m with 30 sec. rest

- Like backstroke, work on hard swimming with about 30 seconds of rest. Breaststroke is very taxing when done hard but like bicycling it is easy to throttle back and have the appearance without the substance.

Integrated Workouts

For pool training it is necessary to integrate your sets into a comprehensive workout. At first you will want to limit your hard sets, but as your fitness improves, hard drills can be extended. It also worthwhile alternating between anaerobic and aerobic workouts. In this way your performance for combat swimmer operations should be optimized.

Figure 5-3. Sample Anaerobic and Aerobic/ Endurance Swim Interval Workouts

Anaerobic

600 m warm-up

5 x 50 m with 15 sec rest between each

5 x 50 m with 30 sec rest

5 x 50 m freestyle swim with 45 sec rest

200 m easy swim

5 x 100 m freestyle, 45 sec rest

5 x 100 m freestyle with 90 sec rest

500 m easy swim

Aerobic

400 m warm-up

5 x 200 m freestyle with 30 sec rest

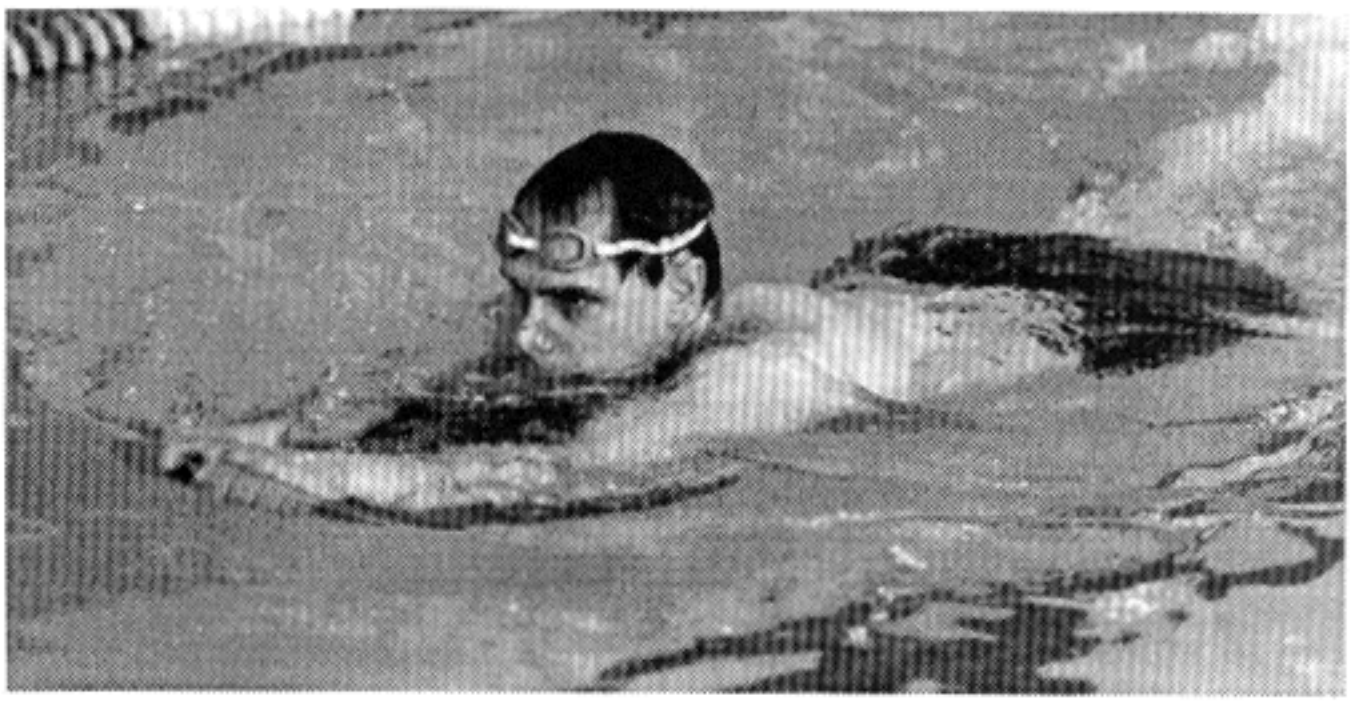
10 x 100 m freestyle, keep distance pace, 10 sec rest

200 m easy swim

5 x 200 m freestyle with 5 sec rest

10 x 100 m freestyle, keep distance pace, 5 sec rest

400 m cool down



Underwater Training

Swimming underwater requires breathholding. While this is an activity that is not endorsed by the diving manual, it may be something you will need to do as a SEAL. Given this fact, specific training will enhance your performance and extend your operational capabilities. The following rules apply to underwater swim training:

- DO NOT hyperventilate prior to your underwater swim.
- Use a buddy to observe during pool drills.

Varying Your Workout

Swimming workouts should be varied between easy days and hard days. For competitive speed, it is good to swim at least four days a week; this will help keep stroke efficiency. Swimming days provide good relief for tight muscles generated by running and weight training.

Swimming has some specialized weight training techniques. The primary issue is that swimmers have full range of motion of their arms during exertion. Muscle contraction is fairly constant over the entire arm motion requiring balanced power throughout. Weight training must complement this fact, or muscle tightness develops that actually works against the swimmer (see Chapter 6).

Pulley pulls are excellent weight training techniques for a swimmer. The classic is the lat pull-down station present in virtually all weight rooms and multi-station machines. A better arrangement is for weights and pulley setups to be individualized for each hand. Pulley pulls are "isotonic" and mimic the constant resistance of water. Weights should be kept on the low side, permitting high speed weightlifting of between 1-1.5 seconds per repetition. Hold slightly at the end of each lift to prevent banging weights and getting thrown out of the weight room.

Swimmers use high reps, never less than 10.

Many dedicated swimmers own an Exergenie, which is a truly simple piece of equipment that permits a realistic workout in freestyle or backstroke. It is a nylon line rigged up through a little cylinder that twists the line and provides resistance. This workout is possible even within the confines of a cramped 688 class (40 - 50 reps) can be done daily because the motion is so much like swimming. Thus, it is a portable weight room for swimmers.

Cross training includes canoeing, rowing, kayaking, and cross country skiing.

All of these involve repetitive arm use in a pattern that is generally complementary to a swimmer's stroke. These sports will impart strength to the shoulder and chest muscles that will help your swimming.

Developing Stroke Skills

Basic stroke mechanics will prohibit you from increasing your respiratory rate (except during backstroke). Because you can't pant, you will quickly become limited by not getting enough oxygen or not getting rid of carbon dioxide before it starts building up. This is different than in running and is the reason for the universal use of interval training in swim training programs. Runners often go out for long steady runs, but a swimmer who trains this way becomes a slow and inefficient swimmer. While operational SEAL swimming is a long, slow activity, it is best for you to acquire a broad base of swimming skills. This will increase your efficiency during SEAL operational swimming.

This section will discuss three main swimming strokes; *crawl stroke* (usually called freestyle or "free"), *breaststroke*, and *sidestroke*. These particular strokes are the most useful to you as a SEAL. Most swimmers use a variety of strokes in a workout to provide cross training and avoid overuse injuries. Skills must be developed over a long period of time in order for the swimmer to become proficient. Good stroke mechanics are not only necessary to develop speed; injury may occur in swimmers from poor technique. A proper stroke may only be developed by getting feedback from others. This factor makes a buddy system or partner coaching an essential component of your training program. Obtain periodic stroke coaching from a qualified instructor - no matter how good you are.

General Stroke Principles

Water causes a large amount of drag on the swimmer's body, thus streamlining becomes extremely important. The key to swimming fast is reducing drag as much as possible while maximizing propulsive forces. One specific technique includes rolling from side to side to clear high resistance parts of the swimmer's body for arm recovery. Swimming in salt water is faster than swimming in fresh water because of the increased buoyancy of the swimmer, reducing resistance. There are many other subtle ways to reduce water drag in swimming, and learning them is one of the benefits of getting coaching from a qualified instructor or swimming coach.

The Strokes

Freestyle

For beginning freestyle swimmers, a pullbuoy will help the swimmer concentrate on proper arm stroke and additionally, help keep the hips positioned high in the water which minimizes drag. Approximately 90% of the work with the freestyle is due to the arm stroke.

The correct arm pull incorporates several elements of sculling. In overall terms, the arm of the swimmer resembles a turning propeller. The diagrams in Figure 5-4, Figure 5-5, and Figure 5-6 outline the hand motion relative to the water, and present front, side, below the water views of the free-style arm stroke of Mark Spitz, as analyzed by swimming physiologist, James Counsilman. Notice the circular motion of the swimmer's arm.

Figure 5-4. Comparing the Free-Style Stroke to the Blades Turning on a Propeller

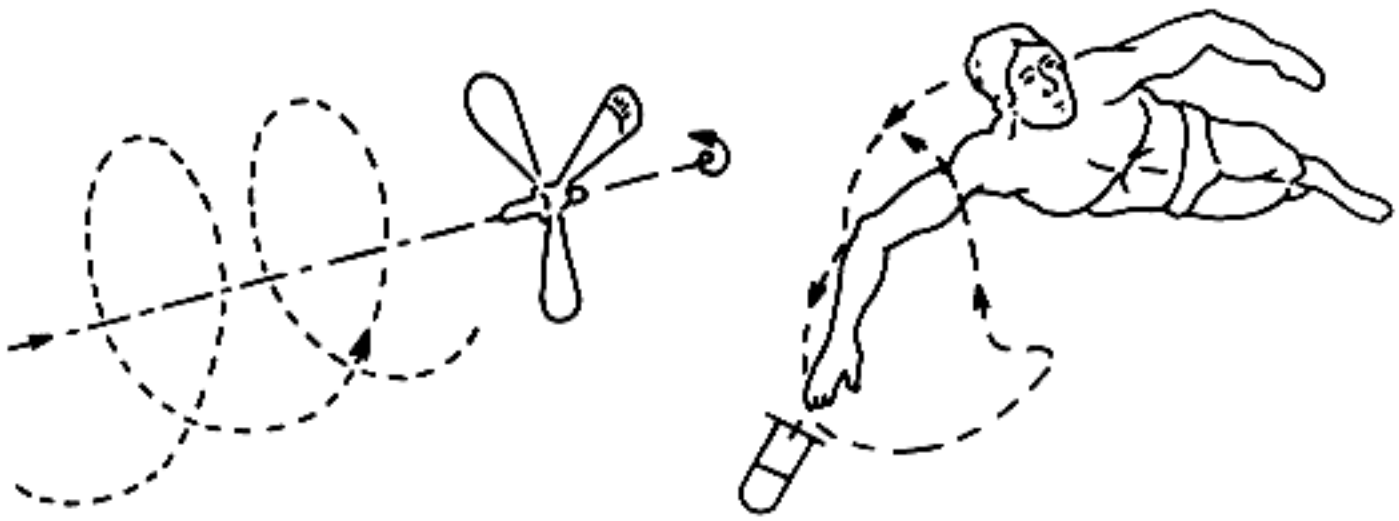
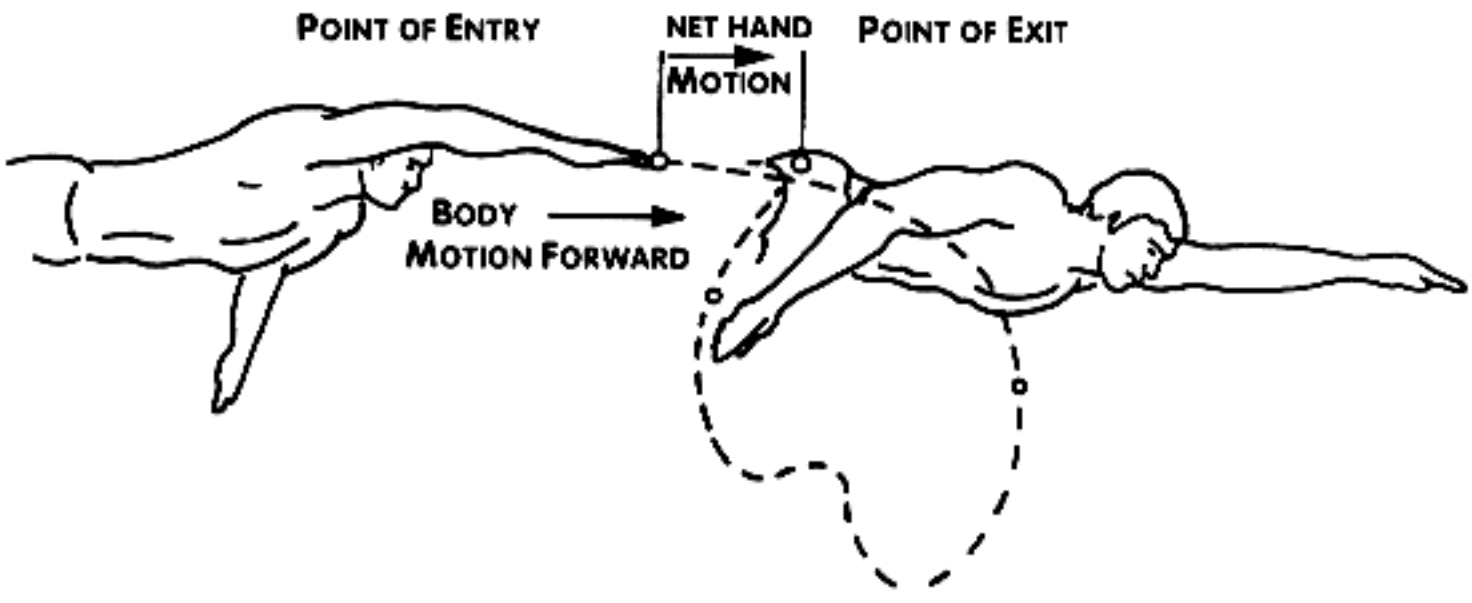
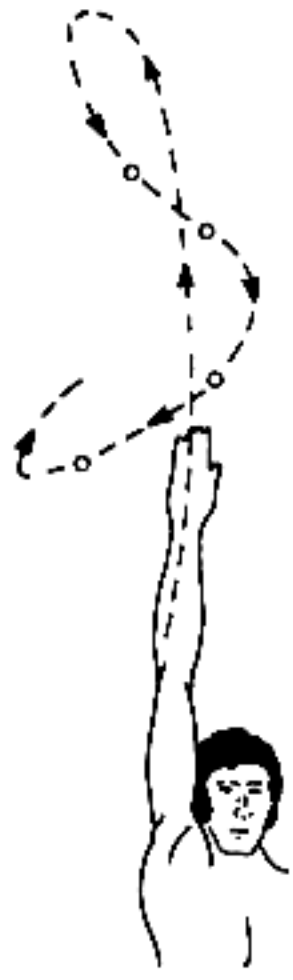


Figure 5-5. The Free-Style Stroke of Mark Spitz



In Figure 5-5 you can see the "catch" that a championship swimmer develops as he sculls downward at first and then sweeps his hand quickly back toward his body.

As shown in Figure 5-6, you can see how the hand is used to seek out still water from below the swimmer. The swimmer initially sculls outward, then he directs his hand inward at the same time he is "catching" back upward toward his body. The freestyle stroke is then completed with an outward scull.



This view shows best the "S" shape of a proper pull. Keep in mind that the "S" occurs in both the horizontal and vertical planes - a very complex motion indeed! You can appreciate how necessary coaching is in developing a proper arm stroke.

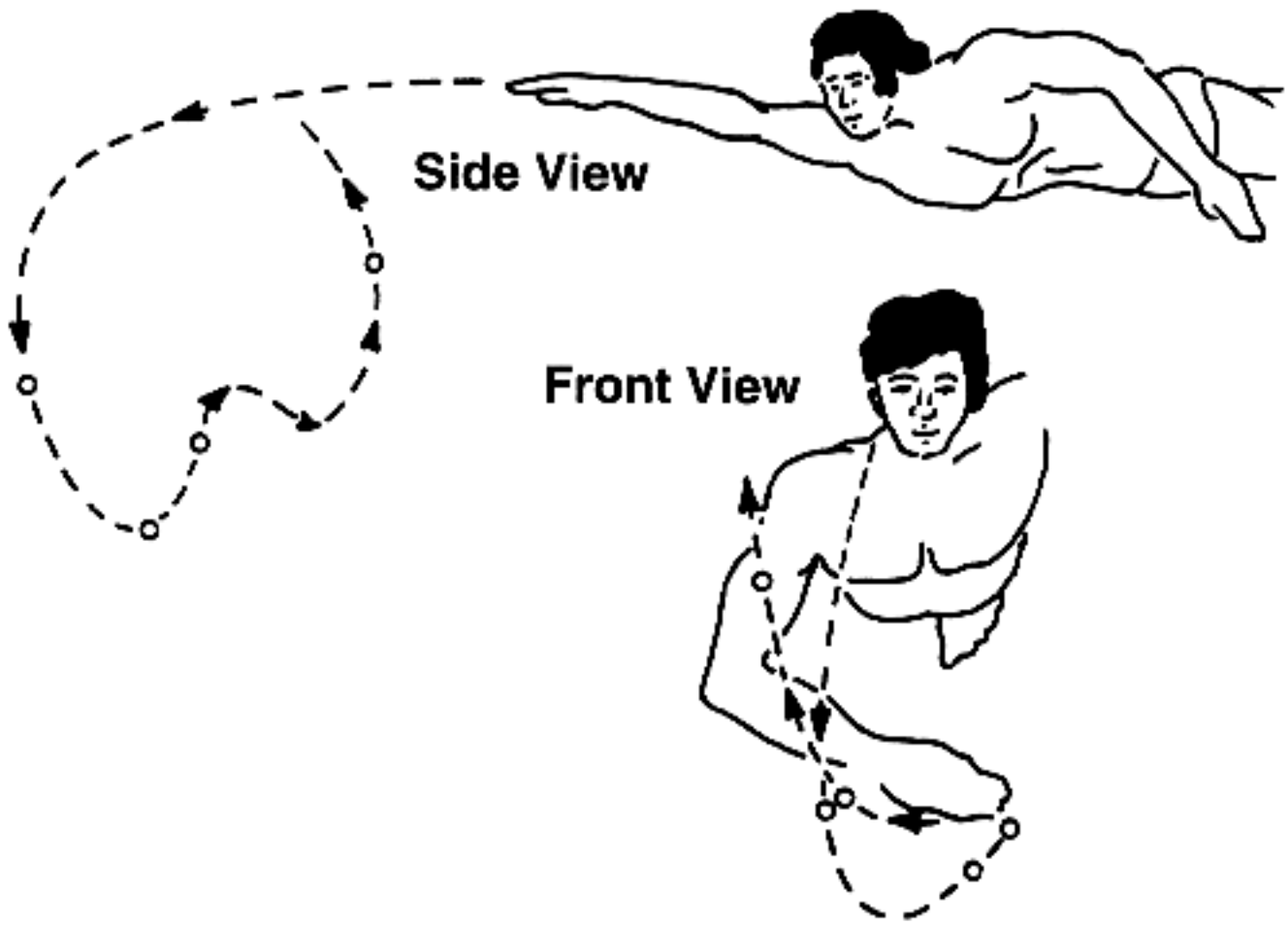
Several of the drills are designed to break this down for you. One arm freestyle allows you to concentrate on the arm's motion. Catchup freestyle slows everything down so that you can coordinate body roll with arm pulls. Using hand paddles will help you feel the water and the sculling sensation is also greatly accentuated.

Figure 5-6. Below the Swimmer View of Mark Spitz's Free-Style Stroke

Using hand paddles will help you develop a strong sculling motion.

Other views (Figure 5-7) show how the arms move during the freestyle stroke. From the front, the hand roughly describes a loop. Finally, you can see again from a side view of Mark Spitz that there is an aggressive "catch" action in the arm pull as he sculls back toward his body.

Figure 5-7. Side and Front Views of Mark Spitz's Free-Style Stroke



Breaststroke

The key to breaststroke is the kick. Propulsion is provided by drawing the feet up towards your body in the direction of motion, and then sweeping both feet backward in a circular motion, pushing motionless water backward with the inside and bottom portions of the swimmer's feet. Coaching is essential to develop good technique as the kick is very subtle.

Pulling is done by a sweeping sculling motion. A good stroke drill to work on for a strong sculling motion is to use only your arms and not your legs, in other words, "pull breaststroke". This drill develops a feel for the water that is needed for all three strokes.

Sidestroke

Sidestroke is extremely important for you to master. SEALs are required to swim in open water under challenging conditions. Arm pulling and kicking should be coordinated to maximize thrust and conserve energy over a long swim. It is necessary to learn sidestroke using either side in order to be able to face away from heavy ocean chop and swells. You can't afford to have a favorite side.

Sidestroke is a "stealth" stroke, unlike freestyle. SEALs can stay in contact with each other over a long swim distance. The sculling motions that have been diagrammed in this chapter for freestyle, also apply to sidestroke. Use a sweeping action with your hand and visualize that your upper hand is like a helicopter blade grabbing still water out in front of you while your bottom hand grabs water ahead and below you.

The power of fins can be used with your flutterkick, not broaching on the surface of the water. Sidestroke is efficient, conserving your energy over a long swim. With fins, the majority of thrust comes from the legs and arm stroke is less important.

Swimming Drills

Fin Drills

Kicking with fins is fantastic training. Be careful of using a kickboard too much while training with fins; this may cause back pain. Sidestroke is good but you will need lane lines and flags to prevent careening off course and acquiring a nice scalp laceration. The mainstay of kicking strokes is still prone flutterkick.

Fin kicking drills are essential to building leg strength and specific training for SEAL combat swimmer duties. These drills are effective when imbedded within a pool workout where there are swimming sets that accentuate arm and chest muscle training. This is because the swimmer's legs will be warmed up but relatively fresh and ready for a strenuous workout with fins. Use high numbers of repeats in sets, 10-12, with relatively short rest intervals of 10-15 seconds. A total set length of around 10 minutes is optimal; any longer and the set begins to degrade into a long, slow distance set which is best done in open water.

- **Fin Sprints**: Sprinting 25 meters with fins will allow you to feel flaws in your arm strokes. This drill will consume an extraordinary amount of oxygen and provide a good anaerobic and strength workout for your legs. It also feels great to go fast.
- **Fin Fartlek**: Do this set without a kickboard. Kick one length with an easy flutter kick, then flutterkick the next length on your right side with both hands out of the water - effort level high - then back to face down for a length of easy flutter kick, then back at it over a hard length, this time on your left side, again hands out of the water. Repeat several times. This drill is particularly effective in a long pool (45m).

- **Fin Repeats**: Do with a kickboard. Kick flutterkick hard for 50m, rest 10 seconds, repeat for 10 repetitions.

Other Specific Freestyle Drills

- **One Arm Freestyle:** May be done with or without a pull-buoy. Emphasizes body rolling without corkscrewing. This drill will allow the swimmer to concentrate on proper pulling technique.
- **Catch-Up Freestyle:** Hold arm out in front while pulling with the other arm. Recover the pulling arm and then touch hands out in front before initiating the pull with the other arm. This drill will help timing of pull.
- **Fist Freestyle:** Swim with fists. This will make the swimmer concentrate on forearm sculling. Do this drill without the pull-buoy.
- **Finger Drag Freestyle:** Recover arm with fingers skimming the water. This provides the swimmer with feedback regarding arm and hand position during arm recovery.

Common Problems

Swimmers often develop hypersensitivities and allergies with pool swimming. The source of the problem is the inhalation of chlorinated organic material (guess where this comes from in a public pool). These hypersensitivity reactions may include lung conditions that are quite disabling. Prevention is the key. Ways to minimize your chances of such problems include:

- Wearing goggles.
- Using a nose clip.
- Avoiding any situation where you might breathe a mist or spray that is generated from pool water.

Chapter 6

Strength Training

Muscular strength and endurance training enhance agility, speed, strength, and endurance, all of which are essential to the SEAL operator. This chapter will help to establish an understanding of the principles of muscle strength and endurance training and their application in the use of weight equipment. The focus of strength training should be its functional use for specific missions. Pure strength alone will not improve mission performance, but conversion of strength to muscle endurance should. The main objective of your strength training program should be to increase your applied strength - an increase in applied strength will enhance your performance on physical tasks required during missions. As such, this chapter introduces concepts and practical information for achieving optimal muscle strength and endurance for job performance and prevention of injuries.

Weight Training Gear and Equipment

Weight training requires minimal personal gear. Other than the weights themselves, equipment such as a pair of supportive shoes, fitted lifting gloves, and standard PT attire is all that is needed. A weight lifting belt should be used for back protection.

Technology has allowed the development of exercise equipment that efficiently adapts to the changing needs of a body in motion. Consider the choice of free weights, machines, or a combination of both for development of strength and balance when starting a weight training regimen. Table 6-1 presents a comparison of free weights and machines.

Table 6-1. Free Weight and Exercise Machine Comparison

Issue	Free Weights	Exercise Machines
User Friendliness	Usually available; Require minimal space; Require spotters for some evolutions	Must have access to sophisticated equipment; Doesn't require spotters
Skill	Require more skill than machines	Require less skill than free weights; Easy to use
Type of Movement	Dynamic	Limited range of motion
Variety in Workout	Allow for a variety of exercises; Useful for correcting strength imbalances between muscles on both sides of the body	Provide variable resistance; Availability of equipment may limit variety
Application	Primary muscles plus peripheral muscles	Tend to isolate muscles

Strength Training Guidelines and Terms

Performing operational tasks requires all muscles of the upper and lower body to be developed in a balanced way. *Circuit weight training or Split-routine workouts* are the most common ways to maintain a musculoskeletal balance. Circuit weight training consists of a progression from one station to the next such that over the course of the training period, both the upper and lower body are exercised. For split-routine training, different body areas are exercised on alternate days. For example, on Monday and Thursday, the upper body would be exercised whereas on Tuesday and

Friday the lower body would be exercised. By having a well designed strength program, you can expect to maintain a high level of fitness while reducing your risk of injury and fatigue.

Repetition Maximum or RM

One term routinely used in strength training is that of repetition maximum. **A repetition maximum or RM is the maximum amount of weight you can lift for a given number of repetitions.** For example, your 1RM would be the amount of weight you could lift for only 1 repetition. Your 5RM would be the amount of weight you could lift for 5 repetitions. For example: if a SEAL can do 5 repetitions of an exercise with 50 lbs., he has a 5RM of 50 lbs.

Your 1RM would be the amount of weight you can lift for only 1 repetition

FITT: Frequency, Intensity, Time, Type

In order for the SEAL operator to perform mission-related tasks, strength training is a key aspect that must not be overlooked. Understanding the concepts of **Frequency**, **Intensity**, **Time**, and **Type** (**FITT** principle) will help you understand and maximize your training.

The **FREQUENCY** of training should be determined by the amount of time one has to spend on strength training. As SEAL operators, your weight training time is limited due to busy schedules, so keep this in mind when your start a program. For example, total body circuit training only needs to be performed twice a week, along with other training modes for optimal results. If two days of training cannot be achieved, one session will be better than none. Split-routine training should be performed a minimum of two sessions per muscle group weekly to ensure total muscular balance, and thus consumes a greater amount of time than circuit training.

Circuit weight training optimizes the time available for SEAL operators.

Training **INTENSITY** is considered to be the most critical aspect of strength and conditioning. Intensity of weight training can be referred to as load, which is the amount of weight per repetition. It is defined as the percentage of the RM that is being used to perform an exercise. Various intensities are recommended for optimal results. The program phase focusing on muscular endurance would involve training at 30% to 50% of your 1RM with 20 to 60 repetitions per set, whereas the phase focusing on strength

with 20 to 60 repetitions per set, whereas the phase focusing on strength development would require training at 65% to 90% of your 1RM, with 1 to 12 repetitions per set, depending on the week of training (Table 6-1). SEAL training should focus on both strength and muscular endurance, and cycle between 30 and 90% of maximal strength. This approach will yield maximum results and increase your performance as a SEAL operator.

The **TIME** you spend on weight training might vary depending on the program chosen. Generally, 30-60 minutes is sufficient, whether a circuit or split routine is implemented.

The **TYPE** of exercise will vary throughout your strength program and can include free weights or machines. For platoon evolutions, circuit training is more adaptable, while split routines may be used for individual strength programs. Figure 6-1 provides an example of the **FITT** principle.

Strength training, along with various other mission-related practices (such as obstacle courses, swims, runs, jumps, and climbs) will develop an overall well-conditioned SEAL operator.

Figure 6-1. Applying the FITT Principle to Total Body Circuit Weight Training

Total Body Circuit

F: 2 times weekly

I: 30% to 90% of 1RM

T: 30 to 60 minutes

T: Circuit weights

Muscle Balance and Exercise Selection List

It is extremely important to consider muscle balance when designing your workouts. Building strength in the triceps should be balanced by strengthening the biceps, and strengthening the quadriceps should be balanced by strengthening the hamstrings. **Without proper balancing of opposing muscle groups, you become vulnerable to injury.**

The main goal of a weight training regimen is to produce a gain in overall strength for operational tasks.

Many exercises can be incorporated into your strength training program. **Table 6-2 presents a list of exercises by specific body parts, all of which are demonstrated in Appendix A**. This translates into a complete body workout from the calves to the neck.

Table 6-2. Exercise Selection List by Body Part

Body Part	Exercises	
Legs:	Squats	Leg Extensions
	Leg Press	Leg Curls
	3/4 Squat	Leg Press
	Standing Calf Raises	
Back:	Curl Grip Lat Pulldown	One Arm Dumbbell Row
	Reverse Barbell Row	Hyperextensions
Chest:	Bench Press	Incline Dumbbell Press
Shoulders:	Behind-the-Neck Press	Upright Row
Arms:	Triceps Pressdowns	Curls

Determining Repetition Maximums

The purpose of knowing your RM is to allow you to adjust the exercise intensity. As a safety measure, it is best to start out by determining your 5RM. To do this, you should have not had any strenuous activity on the day of the test, and you should be properly warmed up. A spotter should always be available when conducting this test. Free weights are the recommended form of weight for this test.

- Select a weight you know is light enough for 10 repetitions.
- Perform 10 - 15 repetitions with that weight.
- Rest for two minutes.
- Increase weight 2% - 10%, depending on difficulty of previous set.
- Perform 6 - 8 repetitions.
- Rest for two minutes.
- Increase weight 2% - 10%, depending on difficulty of previous set.
- Rest for three minutes.
- Perform 5 repetitions - this should be close to your 5RM.

Perform sets with increasing weights and decreasing repetitions until a weight that can be comfortably handled for 5 reps is reached.

Table 6-3 provides an example of how you might determine your 5RM for the bench press, starting with a weight of 110 lbs. Typically, your 5RM is 87% of your 1RM, and your 10RM is 75% of your 1RM. Thus, if your 5RM is 160, your 1RM would be approximately 184 lbs, and your 10 RM would be about 138 lbs. After determining your 5RM, it will be easy to establish your 1RM and loads for workouts (See Figure 6-2). See Table 6-4 for intensity as a percent of maximum strength, repetitions, energy systems, and rest intervals. Remember, the three energy systems are:

- ATP-PC System for speed work activities, such as sprinting.
- Lactic Acid and ATP-PC System for all-out exercise that continues beyond 30 seconds, but lasts less than 3 minutes.

- Oxygen system for aerobic energy to support long-term steady state exercise, such as long distance running or swimming.

Multiply your 5RM times 1.15 to establish your 1RM.

Figure 6-2. Determining Your 1RM from 5RM

5RM = 75
1RM = 75 X 1.15 = 86
5RM = 136
1RM = 136 X 1.15 = 156

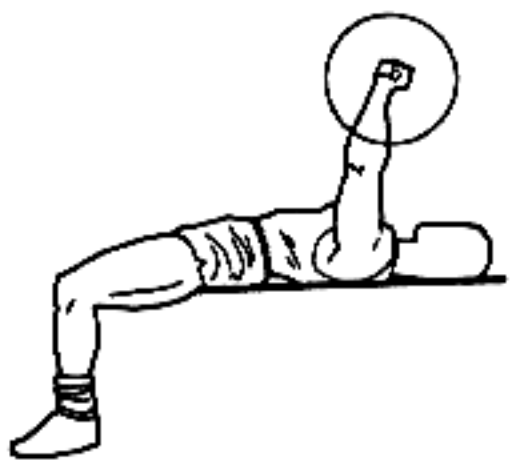


Table 6-3. How to Determine Your 5RM for a Bench Press

Set	Repetitions	Weight	Rest Intervals Between
		10 Minute Warm-Up	
1	12 - 15	110 lbs	2 minutes
2	10 - 12	120 lbs	2 minutes
3	6 - 8	135 lbs	3 minutes
4	5	160 lbs	Completed

Table 6-4. Intensity Levels Relative to a 1RM*

% of 1RM	Number of Repetitions	Rest Intervals Between Sets (minutes)	Energy System
≥ 95	1	3 - 5	ATP/CP
80 - 95	2 - 5	3 - 5	ATP/CP
65 - 80	6 - 10	2 - 4	ATP/CP/LA
50 - 70	8 - 15	2 - 4	ATP/CP/LA
30 - 50	15 - 60	1 - 2	LA/Aerobic

*Adapted with permission from *Strength Training for Sports*; Applied Futuristics[SM], Inc.

Periodization

Periodization of training is a technique that involves altering training variables (such as the number of repetitions per set, the exercises performed, training intensity, and the amount of rest between sets) to achieve well-defined gains in muscular strength, endurance, and overall performance. For example, if you were working towards a particular mission or athletic competition, you would want to peak at that moment and not earlier. Your training schedule would be adapted to achieve that goal.

There are several phases to periodization and weight training in general. The first phase is one of activation, or getting the body ready for a new activity. It would typically last four weeks. Most of you are already weight training and thus have completed the true activation phase, but it is okay to start anew. The second phase is for strength development, and it would last about 4 to 7 weeks, depending on how long you have been weight training. The next phase is the muscular endurance phase, and lasts 8 to 12 weeks, depending on your schedule. Table 6-5 presents a one year plan for training, with three seven week periods of strength development followed by 12 weeks of conversion to muscular endurance. Note that this schedule can be modified, and is presented here to emphasize the concept of periodization.

The goal of the muscular endurance phase is to take strength gains and convert them into applied strength for operations.

Table 6-5. An Annual Plan for Activation, Strength Development and Muscular Endurance*

Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	August
Develop Strength		Muscle Endurance			Develop Strength		Muscle Endurance			Cross-Training/ Active Rest	Develop Strength

*Adapted with permission from *Strength Training for Sports*; Applied Futuristics[SM], Inc.

Training intensities should be varied weekly, depending on whether you are in the strength or muscular endurance phase. Table 6-6 and Table 6-7 present the percent of maximum (%1RM) and number of sets for the strength and muscular endurance phases, respectively. These templates can serve as guidelines for creating your own periodized program. Remember, this program should be followed two times per week.

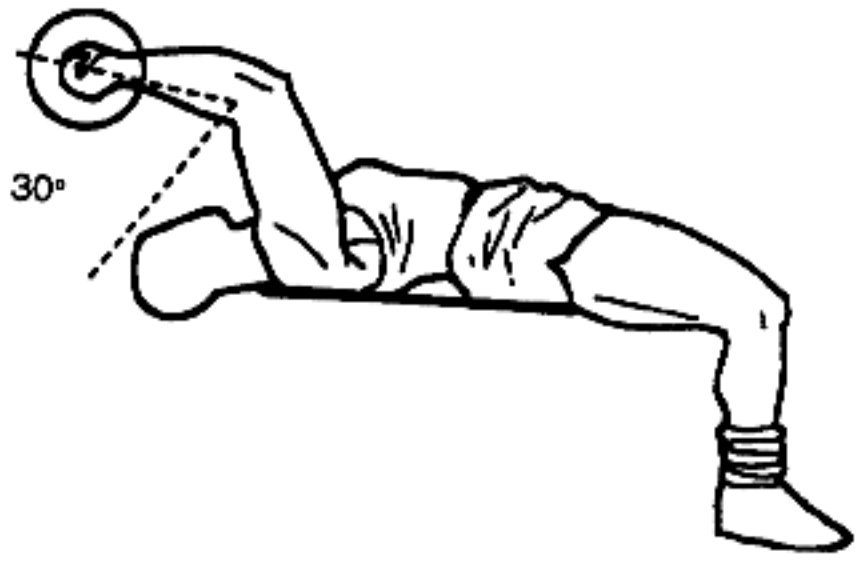


Table 6-6. Strength Development Phase: 2-Day Circuit Weight Training Routine

Week	Set 1	Set 2	Set 3	Set 4	Set 5
	Perform a 5RM test to start Week 1				
1	50% X 12	70% X 8	70% X 8	80% X 6	80% X 6
2	50% X 12	70% X 8	80% X 4-6	80% X 4-6	85% X 3-5
3	50% X 12	75% X 8	85% X 3-5	85% X 3-5	90% X 3-5
4	45% X 15	75% X 6-8	75% X 6-8	80% X 4-6	80% X 4-6
5	55% X 12	75% X 8	85% X 3-5	85% X 3-5	85% X 3-5
6	55% X 10	75% X 8	85% X 3-5	90% X 1-3	90% X 1-3
7	55% X 12	75% X 6-8	75% X 6-8	80% X 4-6	80% X 4-6

Table 6-7. Muscle Endurance Phase: A 2-Day Circuit Weight Training Routine

Week	Set 1	Set 2
	Perform a 5RM test at Week 1 Start at 30%: Reps are more important than%	
1	30 - 50% X 20	30 - 50% X 20
2	30 - 50% X 30	30 - 50% X 30
3	30 - 50% X 40	30 - 50% X 40
4	30 - 50% X 35	30 - 50% X 35
5	30 - 50% X 45	30 - 50% X 45
6	30 - 50% X 50	30 - 50% X 50
7	30 - 50% X 40	30 - 50% X 40
8	30 - 50% X 55	30 - 50% X 55
9	30 - 50% X 60	30 - 50% X 60
10	30 - 50% X 50	30 - 50% X 50
11	30 - 50% X 40	30 - 50% X 40
12	30 - 50% X 30	30 - 50% X 30

Although it may seem a bit foreign to you to see up to 60 reps per set in Table 6-7, this is the best way to convert your strength gains to applied strength, or functional strength. You will be amazed at your muscular endurance and ability to perform mission-related tasks and other strenuous physical tasks, if you truly stick with a program such as this

Weight Lifting Techniques

Correct lifting techniques are critical for achieving maximum benefits and preventing injury. Lifting form, speed, and breathing techniques are all important for weight training. The lift should be performed as a controlled movement with proper form. Do not compromise your form as it will not help but rather increase your chance of injury. The appropriate speed of lifting needs to be applied to all exercise movements. When performing exercises, such as the bench press, squat, biceps curl, lat pull-down, etc., the weight should be moved at a rate of 1-2 seconds in each direction. This will ensure your safety and optimize strength training.

Controlling the rate of movement affects the muscle you intend to strengthen.

Always make use of a spotter if you are using free weights. Refer to Appendix A for form illustrations and instructions, so you can change your technique if you are not following the proper directions.

Exhale when moving a weight against gravity.

Proper breathing techniques must be used during weight training. Exhale during positive weight movement (moving the weight against gravity). This helps prevent the valsalva maneuver (an increase in internal pressure caused by holding your breath during lifting exercises) which can result in damage to the cardiovascular system. Never hold your breath while performing any exercise task.

Types of Workouts

A *Circuit Routine Training* for the first week of the strength development phase and muscular endurance phase is presented in Table 6-8 and Table 6-9, respectively. Workouts for the other weeks can be obtained by reviewing Table 6-6 and Table 6-7. Remember, periodization is the key to improving overall muscle strength and endurance.

Table 6-8. Week 1: Circuit Training Strength Development Phase

Exercises	Sets (% of 1RM and Reps)				
	1 (%/Reps)	2 (%/Reps)	3 (%/Reps)	4 (%/Reps)	5 (%/Reps)
Squats or Leg Press	50/12	70/8	70/8	80/6	80/6
Curl Grip Pulldowns	50/12	70/8	70/8	80/6	80/6
Leg Curls	50/12	70/8	70/8	80/6	80/6
Bench Press	50/12	70/8	70/8	80/6	80/6
Standing Calf Raises	50/12	70/8	70/8	80/6	80/6
Behind-the-Neck Press or Upright Row	50/12	70/8	70/8	80/6	80/6
Tricep Pressdown	50/12	70/8	70/8	80/6	80/6
BB Curls	50/12	70/8	70/8	80/6	80/6

DB = Dumbbell; BB = Barbell; See Appendix A for pictorial representation.

Table 6-9. Week 1: Circuit Training Muscle Endurance Phase

Exercises	Set 1 (%RM/Reps)	Set 2 (%RM/Reps)
Squats or Leg Press	30-50/20	30-50/20
Curl Grip Pulldowns	30-50/20	30-50/20
Leg Curls	30-50/20	30-50/20
Bench Press	30-50/20	30-50/20
Standing Calf Raises	30-50/20	30-50/20

Table 6-9. Week 1: Circuit Training Muscle Endurance Phase

Exercises	Set 1 (%RM/Reps)	Set 2 (%RM/Reps)
Behind-the-Neck Press or Upright Row	30-50/20	30-50/20
Tricep Pressdown	30-50/20	30-50/20
BB Curls	30-50/20	30-50/20

DB = Dumbbell; BB = Barbell; See Appendix A for pictorial representation.

Warming Up

It is imperative to warm-up prior to a strength training workout. An active and dynamic warm-up will elevate the body temperature so that the muscles respond better to the training. An increase in circulation to the joints and tissues allow more elasticity and may decrease the risk of injury. The warm-up should last long enough to break a sweat then stretching should be initiated. Thus, the major component of a warm-up session for weight training is a cardiovascular workout, or a general warm-up designed to increase your circulation and direct blood flow to the muscles for the upcoming workout. This should be low intensity exercise for 10 to 20 minutes.

- Biking
- Stairclimber
- Treadmill/Jogging
- Jumping Rope
- Rowing Ergometer
- Jumping Jacks/Calisthenics
- One or Two Exercises with Light Weights

Cooling Down and Stretching

Upon the completion of a training routine, cooling down and stretching should not be overlooked. The cool-down should be gradual to normalize body temperature, prevent pooling of blood in the muscles and return metabolic rates to pre-exercise levels. It also speeds the removal of waste products which tend to increase muscle soreness and prolong recovery. Stretching after weight training maintains joint and muscle flexibility while minimizing muscle spasms and weight training injuries. In brief, the components of a cool down include:

- Low intensity cycling or walking
- Complete body stretching
- Relaxation

Common Problems

You need to listen to your body and be able to recognize the signs of problematic conditions associated with weight training.

- **Injuries** - Lack of warm-up and improper lifting techniques (form) can cause muscle damage.
- **Overuse Syndrome** - occurs when you engage in frequent repetitive exercises to a specific area or use an improper technique during an exercise. The knee, elbow, and shoulder are most susceptible to these injuries.
- **Delayed Onset Muscle Soreness (DOMS)** - potentially severe pain experienced 24 to 48 hours after the activity.

In order to allow the body to heal, the improper routine and/or techniques must be altered. Proper technique, progression, variation, rest and recovery will minimize training related injuries. More information can be found in the training related injuries chapter.

Conclusions

Strength training with weights is an important component to the complete PT program of the SEAL operator. Training with weights 2-3 times per week can help optimize preparations for mission-related tasks. It is important to understand that one should focus on the SEAL mission when developing a weight training regimen. A proper weight training routine will help prevent injuries and accelerate recovery from an injury to the musculoskeletal system. Following the principles and examples in this chapter will help you develop a well balanced lifting routine. Optimal conditioning can be obtained without injury to the body if weight training is included in your overall "PT" program.

Resource

- Fred Koch, *Strength Training for Sports*; Applied Futuristics[SM], 1994.

Acknowledgment

The editors thank Mr. Fred Koch for sharing his expertise and experience in strength training. His comments and suggestions were invaluable to the development of this chapter.

Chapter 7

Flexibility

Most trainers, exercise physiologists, and health care professionals agree that flexibility training, although often overlooked, is an important component of a physical fitness program. Stretching becomes even more important as athletes and/or SEALs achieve advanced levels of muscle strength and endurance. If optimum performance is the goal, then adherence to a consistent flexibility program is required.

Flexibility Benefits

Proper use of stretching increases flexibility and provides the following benefits:

- Improved performance
- Reduced potential for injury (i.e., muscle strain or sprain)
- Reduced muscle soreness
- Decreased risk and severity of low-back pain
- Increased agility
- Increased blood flow to the joints

Proper physical conditioning is necessary for successful mission performance. Flexibility is an integral part of a conditioning program and enhances performance by extending the range of motion in which one can optimally perform. SEALs are at high risk for musculoskeletal injuries. Joint

stability and consequent protection against injury are best achieved through a balanced physical conditioning program designed to improve both muscle strength and flexibility. Strength and flexibility training should be considered interdependent since both are involved in the degree and quality of movement across a joint.

Muscles that are strengthened should be stretched, and vice versa. An intense strength workout can cause microtrauma to the muscles, and the process of recovery can shorten the muscles and connective tissue. Stretching prevents this shortening which could contribute to muscle strains or other overuse injuries (e.g., tendonitis, fasciitis).

Flexibility training, without concurrent strength training, weakens the muscles and connective tissue and places the joints and muscles at risk for sprains, partial and complete dislocations, and muscle strains. Strengthening the muscles surrounding a stretched joint helps stabilize the joint and improve muscular function, thus decreasing the likelihood of injury.

Overstretching may lead to injury; however, as long as a flexibility program is well balanced with strength training, this possibility is negligible.

Definition

Flexibility is the ability of a limb to move freely about a joint through a full range of motion.

In the case of Special Warfare Operators, flexibility refers to the optimum range of motion surrounding a particular joint that is necessary for peak performance. Range of motion is specific to each joint and dependent upon:

- Joint surfaces and capsule and the degree of movement required for the joint to function
- Muscles, tendons, ligaments and connective tissue associated with limb movement around a joint (for definitions see Chapter 1)
- Strength of the musculature surrounding the joint

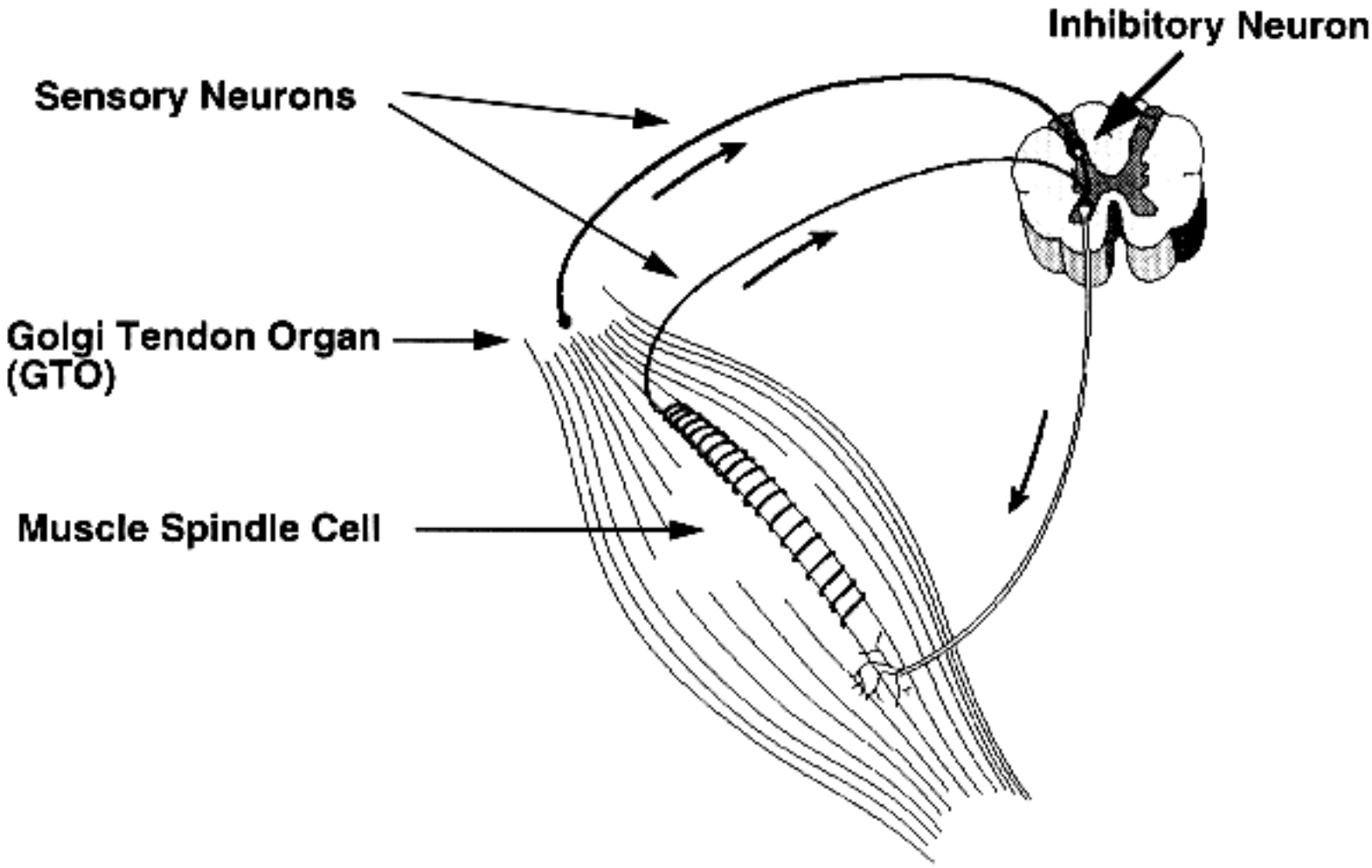
There are two types of flexibility: dynamic and static.

Dynamic or active flexibility refers to the speed attained within a range of motion at the joint during physical performance. This type of flexibility involves the intrinsic musculature surrounding the joint and its ability to overcome resistance to motion. An example would be the flexibility required to throw a baseball, punch a boxing opponent, or perform a martial arts kick. Static or passive flexibility refers to the maximal range of motion of a joint during passive movement induced by an external source (e.g., a partner, equipment, gravity). The range of static flexibility is always greater than that of dynamic flexibility.

The Stretch Reflex and the Lengthening Reaction

The stretch reflex and the lengthening reaction are joint-protective mechanisms in which sensory organs, located in the muscles and tendons surrounding a joint, are activated when muscles are stretched. As seen in Figure 7-1, the two sensory organs involved in monitoring muscle tightness are the muscle spindle cells and golgi tendon organs (GTOs).

Figure 7-1. Graphical Representations of Muscle Spindles and Golgi Tendon Organs



The stretch reflex involves muscle spindles which lie parallel to the muscle fiber. These spindles are very sensitive to changes in muscle length. When the muscle stretches, muscle spindles send signals to the spinal cord, which in turn, sends signals to the muscle telling it to contract in order to protect the muscle from potential tissue damage. The classic example of the stretch reflex occurs when a physician taps a patient just below the kneecap. The quadriceps muscle is quickly stretched, and the muscle spindles react by contracting the quadriceps muscle causing the knee-jerk response. The greater or more rapid the stretch, the greater the response of the muscle spindles and the resultant muscle contraction. Signals are high in frequency at the beginning of a stretch, but then slow down as they adapt to the new length.

The lengthening reaction engages GTOs, which are located in the muscle-tendon junctions, and activates them when the tension in a tendon is increased as a result of either muscular contraction, stretching the muscle beyond its resting length, or a combination of the two. When muscular tension increases, the GTOs respond by sending inhibitory signals to the muscle; this causes the muscles to relax, and protects the muscles and tendons from tearing due to tension overload. Knowledge of the stretch reflex and the lengthening reaction is useful for effective stretching.

The most effective stretches are performed slowly, and held for 15 - 30 seconds.

Performing the stretch slowly avoids excessive activation of the muscle spindles and resultant muscular contraction. Holding the stretch allows time for the muscle spindles to adapt to the new muscle length, and eventually, to achieve greater lengths. The length and duration of the stretch should also be sufficient to activate the GTOs so that they override the muscle spindles and induce muscular relaxation.

Flexibility Training Methods

There are several training methods used to develop flexibility; however, most fall under the following general categories:

- Dynamic
- Static
- Ballistic
- Proprioceptive neuromuscular facilitation (PNF)

Dynamic Stretching

Dynamic stretching (sometimes referred to as active stretching) consists of controlled movements which increase in range and/or speed so that you gradually reach your full range and speed of movement (e.g., slow, controlled leg swings or kicks, controlled arm swings, back bends). This type of stretching often mimics the activity that is to be performed and prepares the muscles for that activity.

There is some controversy surrounding the effectiveness of dynamic stretching and its role in the development of flexibility. Some experts believe that the short, intermittent movements involved in this type of stretching activate the stretch reflex and cause the stretched muscle to contract. Others maintain that dynamic stretching is beneficial for quick, explosive activities like gymnastics or martial arts. However, in general, dynamic stretching should not be used to develop static flexibility or long-standing changes in range of motion. If used at all, dynamic stretching functions best before exercise to enhance performance. This type of stretch is often performed after a warm up and prior to an exercise session in anticipation of a particular activity. Dynamic stretches should mimic the activity that is to be performed.

Static Stretching

Static stretching (sometimes referred to as passive stretching) develops static flexibility and uses slow, controlled movements through a full range of motion. This type of stretch is performed by holding a position using a part of the body, the assistance of a partner, or some other apparatus such as a pole or the floor (e.g., lifting one leg up and holding it with the hand, the splits). Slow, static stretching helps relieve muscle spasms due to exercise, and is used for cooling down after a workout to reduce muscle fatigue and soreness.

Ballistic Stretching

Ballistic stretching uses the momentum of the body or a limb to force a stretch past the normal range of motion and then return to the starting position. Ballistic stretching incorporates bouncing or jerky movements and should not be confused with dynamic stretching. An example of a ballistic stretch would be bouncing down to touch toes or using the momentum of the torso to twist the body. Uncontrolled arms swings in which the arms are thrown backward and then bounce back to the starting position are also an example. This type of stretching does not contribute to flexibility. Instead, the repeated activation of the stretch reflex causes muscles to contract which can lead to injury. **This type of stretching is not recommended.**

PNF Stretching

Proprioceptive neuromuscular facilitation (PNF) stretching is considered an advanced stretching technique. It is used extensively by physical therapists or when high degrees of both passive and dynamic flexibility are required for performance (e.g., martial arts, ballet, gymnastics, kick-boxing). There are several PNF techniques, but generally, PNF consists of a passive stretch, followed by an isometric contraction, which is then followed by another stretch (static or dynamic). By combining passive stretching with isometric contractions (a contraction in which there is no change in muscle length or joint movement) with a partner or object for resistance, PNF uses the stretch reflex and lengthening reaction to achieve a greater range of motion. As described in the section above, when a muscle is slowly stretched and held, the resulting tension triggers the lengthening reaction which prevents the stretched muscle fibers from contracting. When this stretched
muscle is then isometrically contracted, the following happens:

- During an isometric contraction, some fibers will contract, but others will stretch even further. When the contraction is stopped, the contracted fibers return to their starting position, while the stretched fibers retain their stretched position (due to muscle spindle accommodation) and are able to lengthen even further.
- The increased tension within the muscles generated by an isometric contraction activates the GTO which triggers the lengthening reaction, and inhibits further contraction. When the isometric contraction is stopped, the muscle is still inhibited from further contraction and able to lengthen further.

The final stretch, which follows isometric contraction, takes advantage of the muscle's ability to elongate further, and allows the muscle, tendon, and sense organs to adapt to greater lengths.

It is best to have a partner help when using PNF techniques.

A common PNF technique is referred to as the **"contract-relax method".** Instructions for and a pictorial representation of this method are provided in Figure 7-2. This technique uses passive stretch and isometric contractions, followed by muscle relaxation and passive stretching to the new range of motion. For example, if you are stretching your hamstrings, you first passively take the stretch to the point of tightness and hold. Then you isometrically contract the hamstrings by using this muscle to apply force against an object or partner (See Figure 7-2). Following the contraction, the muscle is allowed to relax and the muscle is then passively stretched and

Common Medical Conditions

A number of acute medical conditions are associated with load-bearing. Most are minor, but any one can potentially affect your ability to maneuver quickly and ultimately slow down the walking pace of the squad or platoon. By understanding the range of medical problems, you will be able to better prevent, assess and treat these injuries. These medical conditions are all covered in Chapter 12: Training and Sports Related Injuries. The most common injuries incurred during load-bearing are:

- Foot blisters (See Appendix C)
- Back pain
- Stress fractures
- Rucksack palsy
- Dehydration
- Other minor lower extremity injuries, such as foot and knee pain

Conclusion

Appropriate aerobic and anaerobic training, along with bi-monthly training humps, will improve your ability for load-bearing, lower energy demands, and reduce the frequency of musculoskeletal injuries.

Acknowledgments

BM1 Pete Vernia, USN, Advanced Training Department, SDV Team1

LCDR Bruce Willhite, USN, J-5, Special Operations Command

Joseph Knapik, Ph.D.

Chapter 11
Training for Specific Environments

Physical training in extreme conditions, such as hot, cold, or high altitude environments, presents special challenges. Even highly accomplished athletes can be quickly overcome by "environmental exposure" injuries if proper preparation is overlooked or if signs and symptoms of impending illness are ignored. To compound matters, many extreme environments tend to be isolated and difficult to access. Proper planning and preparation before entering such areas can help ensure safe and beneficial training.

One way of adapting to a new environment is **"acclimation"**. Acclimation is defined as *the continuous or repeated exposure to heat, cold, altitude, or some new environment so as to provoke physiologic or biochemical changes that allow you to better tolerate the new environment.* Thus, acclimation is the gradual change the body goes through as it adapts to a new environment. This chapter will focus on training under environmental conditions which require acclimation, and also under confined spaces.

Training in Hot Environments

Exercising in hot, humid environment imposes a significant challenge on the body. The human body maintains tight control of body temperature through several different mechanisms. Under conditions which impose large heat loads (example: strenuous exercise or wearing protective gear in a hot environment), the primary mechanism for cooling is evaporation of sweat from the skin or evaporative cooling. Relative humidity is the most important factor governing evaporative cooling: when the humidity is high, evaporation is greatly limited.

Your skin is like the radiator of a car; as the temperature of the body core rises it warms the blood and pumps it to the skin to cool off. Sweat is released at the skin and absorbs the heat from the warmed blood. As sweat is warmed, it is vaporized the same way boiling water turns to steam and thus removes a large amount of heat from the body. Only sweat that evaporates can effectively cool the body; sweat that "drips" is essentially wasted fluid and provides little or no cooling effect. The body maximizes evaporative cooling by:

- **Increasing Heart Rate**: An increase in the heart rate increases blood flow to the skin and results in greater heat transfer to sweat and vapor.
- **Increasing Sweat Volume**: Beginning to sweat earlier and recruiting more sweat glands increases the rate of sweat production, therefore cooling.

How hot is too hot? The degree of danger posed by a hot environment is usually determined by the wet bulb-globe temperature (WB-GT). If the WB-GT is over 87° F (30.5° C) or if no WB-GT is available and the temperature is over 85° F with a relative humidity of 60% or above, exercise should be avoided or undertaken with caution.

Factors that Hinder Body Cooling in the Heat

- **Humid Heat**: As the humidity increases, evaporative cooling slows due to saturation of the air with moisture.
- **Skin Disorders**: Injuries such as deep thermal burns, sunburn or rashes will prevent or hinder sweating.

- **Clothing**: Any clothing that is impermeable to water vapor will compromise cooling.

Heat Acclimation

Adapting to a hot environment can take one to three weeks; for physically fit individuals, 75% of acclimation occurs during the first week of heat exposure. During this time, sustained physical activity is more difficult and onset of fatigue occurs with minimal physical exertion. Acclimation involves two parts:

- **Cardiovascular adaptations**: Changes that gradually lead to a lower heart rate for a given workload or intensity of exercise This is the most rapid change during acclimation to heat.
- **Sweating**: Sweating begins earlier with exertion; sweat rate is higher and can be sustained for longer periods of time. Sweat also becomes more dilute thus saving essential body electrolytes.

Maximizing Acclimation

Maintain Aerobic Fitness

A solid base of endurance training established before you enter a hot environment will ease the cardiovascular strain encountered during acclimation. Pre-acclimation endurance training must be rigorous enough to raise core temperatures for acclimation to be most beneficial. Aerobically fit individuals will retain heat acclimation longer once removed from a hot environment than less fit personnel. **Remember:** Aerobic fitness will help speed the acclimation process but is not a substitute for it.

Exercise in a Hot Environment

Any form of physical exercise will hasten acclimation. However, the intensity will be lower than what you are used to. Refer to your local medical officer for guidance. If the environmental conditions permit, gradually increase the intensity of exercise until you reach the desired workload or level of training.

Maintain Adequate Hydration

Acclimation results in an earlier onset of sweating as well as an increase in the sweating rate. These changes translate to an increased need for fluids. Acclimated personnel may produce as much as 8 to 10 liters (8.5 to 10.5 quarts) of sweat per day. Thirst cannot be used as a "measuring stick" for proper hydration. When training in hot environments, a minimum of 10 to 12 quarts of water per day should be consumed, but not more than 5 cups per hour. Drinking at frequent intervals will decrease the risk of a potentially fatal heat stroke.

Maintaining Acclimation

Heat acclimation cannot be maintained unless there is repeated heat exposure and even if repeated exposure is maintained, other factors may cause a loss of acclimation. Factors that lead to loss of heat acclimation include:

- Sleep loss
- Alcohol
- Dehydration
- Salt depletion
- Illness/Infections
- Cessation of physical activity

There is some disagreement as to how long it takes to lose acclimation to heat, but generally speaking after 2 weeks of working in a hot environment, it will take 3 to 4 weeks before most of the adaptations are lost.

Heat Injuries

There are many categories and subcategories of heat injuries. However, there are three classes of heat-induced injury that will be considered here:

- **Heat cramps** are painful contractions of muscles (usually in the extremities) following vigorous exercise. They occur most commonly in unacclimatized personnel. No specific cause is known (possibly depletion of electrolytes), but such cramps usually resolve when acclimation is complete.
- **Heat exhaustion** is a potentially serious injury resulting primarily from dehydration and electrolyte depletion. The affected individual may feel light-headed, dizzy, nauseous, fatigued, or develop a headache. If heat exhaustion is suspected, the injured individual should be placed in a cool location if possible and given replacement fluids by mouth or intravenously.
- **Heat stroke** is a life threatening injury in which the affected individual loses the ability to regulate temperature and is overcome by soaring body core temperatures (greater than 104° F). Such high temperatures can irreversibly injure vital organs and result in death if not rapidly treated. Many factors may contrib-

ute to heat stoke -- even well hydrated personnel may become victims if they ignore the warning signs and symptoms (see the following Table).

Table 11-1. Warning Signs of Heat Stroke

Signs to Be Aware of	
Light-headedness	**Headache**
Confusion	**Nausea/vomiting**
Loss Of Consciousness	**Combativeness**

Immediate medical attention is necessary to prevent death. Always remember the basics of first aid and check the ABC's first (Airway, Breathing and Circulation). If possible, move the injured person to a cool area and remove all of the person's clothing. Wet the body with a fine mist of water or pour cool water over the body and fan to facilitate cooling. If ice is available, apply bags of ice to the arm pits, groin and sides of the neck. Medical personnel should start intravenous fluids and oxygen if possible and transport the individual to the nearest medical treatment facility.

Many drugs and chemicals can decrease your ability to tolerate the heat, and knowing which ones may interfere with performance can be important on missions in hot environments. Table 11-2 presents some of the most common drugs that should be avoided in hot weather.

Table 11-2. Drugs and Chemicals to be Avoided in Hot Environments

Caffeine	**Alcohol**	**Decongestants**
Atropine and other anticholenergics		**Antihistamines**

Summary for Hot Environments

- Prepare by maximizing aerobic fitness -- this will greatly help in sudden in-out ops where gradual acclimation is not possible.
- Plan work-out to avoid heat of the day.
- Optimize acclimation by a carefully scripted exercise program from the medical department.
- Plan for decreased physical performance the first two weeks.
- Maintain proper hydration.
- Be aware of any illness that may predispose to dehydration (diarrhea, vomiting, fever).
- Always be aware of the warning signs of heat illness: Pay attention to your body. Slow down or stop if signs or symptoms of heat injury become apparent.
- Avoid drugs and other substances that predispose to dehydration or heat injuries.

Training in Cold Environments

Cold climates represent the harshest environments and pose the greatest threat to survive that SEALs face. An unprotected man in an extremely cold environment will perish much faster than when exposed to extreme heat. In cold weather, the human body attempts to maintain a warm core temperature primarily by physiologic mechanisms and behavioral adaptations:

- **Increased Metabolic Heat Production**: This occurs as the body's fuels (carbohydrates, fats and proteins) are metabolized or "burned" at the cellular level. Shivering represents involuntary muscle contractions that can increase the body's metabolic rate five to six times above normal.
- **Peripheral Vasoconstriction**: Blood vessels near the surface of the skin constrict or narrow in an effort to divert warm blood away from the cool surface of the skin.

- **Behavioral Adaptations**: Mans greatest asset in cold weather is his ability to create a warm micro-environment by wearing appropriate protective clothing or seeking shelter. He can also increase resting metabolic heat production by 10 times through vigorous exercise.

What is a cold environment? As with a hot environment, the temperature alone is not necessarily the best indication of coldness. In the heat, humidity, and in the cold, the wind, can greatly change your comfort level. In the cold, wind accelerates heat loss by replacing the warm layer of air surrounding the body with colder air. As a rule, you can be sure it is a cold environment when the ambient temperature is below 15° F and the wind speed is greater than 25 mph. Such environments pose potential dangers to those exposed for any length of time.

Factors that Compromise Adaptations to Cold

- **Inadequate Energy Intake**: Reduces the ability to generate "metabolic" heat.
- **Injury or Poor Physical Conditioning**: Inhibits ability to generate heat through vigorous exercise.
- **Dehydration**: Places greater demands on the heart and speeds up fatigue.
- **Low Percentage of Body Fat:** Subcutaneous fat has insulating properties which help protect against heat loss. This is a concern for SEALs, who usually have low body fat.
- **Excessive Sweating**: Dress appropriately using a layering system and ventilate as necessary to avoid excessive sweating. Sweat will destroy the insulating qualities of cold weather clothing and cause unwanted cooling by evaporation and freezing
- **Alcohol**: Increases peripheral blood flow which promotes heat loss and causes core temperature to fall more rapidly.

Acclimation to the Cold

Unlike acclimation to hot environments, there is little evidence to suggest that in humans, there is a significant physiologic adaptation to the cold. There is evidence to suggest that hands which are exposed to the cold

for 30 minutes per day for three weeks will receive more blood flow and gradually become more "functional". However, there is greater heat loss through hands conditioned in this manner.

Cold Injuries

The spectrum of cold injuries experienced in the SEAL community is broad but all can be avoided by wearing appropriate clothing and paying attention for signs and symptoms of cold injuries.

Hypothermia

A lowering of body core temperature below 95° F is not an uncommon cold injury of SEALs and mild hypothermia is a relatively easy injury to treat. Moderate to severe hypothermia is less common and should be treated as a medical emergency. Some warning signs of a falling body core temperature include:

- Uncontrollable shivering
- Slurred speech
- Clumsiness
- Slowed thought process
- If shivering stops but all other signs are present - it could be an indication of severe hypothermia

If any of the above signs occur, **immediate action** should be taken to prevent further injury or death. Always handle personnel suspected of having hypothermia gently - do not allow them to perform vigorous exercise to warm up as this may cause cardiac arrest. Remove wet clothing and place the individual in dry blankets or sleeping bag with one or two other dry and warm personnel. **Never completely immerse a hypothermia patient in warm/hot water as this may result in cardiac arrest.** Passive rewarming is usually satisfactory for mild hypothermia, but may not be adequate for severe cases.

Gentle rewarming is the safest method of restoring normal body temperature.

Frostbite

Frostbite is a freezing injury which most commonly affects the hands and feet. However, it can occur to any surface of the body that is not adequately protected. Symptoms often follow a progressive pattern to include the initial sensation of cold followed by numbness and eventually pain during rewarming. The skin may appear normal or appear pale. **If a frostbite injury is suspected, attempts to thaw the affected tissue should be avoided until there is absolutely no chance of it refreezing.** Frostbitten feet should not be thawed if it is necessary for the injured to walk unassisted to the extraction or medevac site. Rewarming is associated with severe pain and may turn walking wounded casualties into nonambulatory casualties. All cases of frostbite require evaluation at a definitive medical treatment facility.

How to avoid freezing injuries

- Dress appropriately and keep hands and feet as dry as possible.
- Do not touch metal with bare hands/skin. Tape frequently touched metals to reduce this risk.
- Wear protective goggles when exposed to high wind speeds such as in snowmobiles, aircraft, skiers.
- Use the "buddy system" to check each other for unprotected skin.

Immersion Foot

Also known as "trench foot", this nonfreezing foot injury results in tissue and nerve damage after prolonged exposure of wet feet to the cold (32 to 50° F). Immersion foot can be prevented by keeping feet as dry as possible and by avoiding tight fitting boots.

Nutritional Requirements

Special attention should be paid to nutritional requirements in cold environments. Energy requirements may increase several fold because of the increased work associated with performing physical tasks in cold weather and the caloric losses to shivering which can rapidly deplete glycogen stores. Carbohydrates are an excellent source of energy for replenishing depleted glycogen. Refer to the *U.S. Navy SEAL Nutrition Guide* for specific nutritional needs during cold weather operations.

Summary for a Cold Environment

- Check weather conditions and dress appropriately.
- Allow for a longer warm up.
- Avoid profuse sweating.
- Replenish body fuel (carbohydrates) during endurance events.
- Maintain hydration.
- Avoid drugs that cause dehydration: alcohol, caffeine.
- Be aware of the signs of cold injury.
- Use gentle rewarming for hypothermia victims.

Training at Altitude

An athlete's performance can suffer dramatically when he rapidly ascends to altitude. Several factors contribute to this decrement in performance but the most significant factor is the relative hypoxia or lack of oxygen available to do work at higher altitudes. Many changes occur during extended exposure to high altitudes; most occur after 2 to 3 weeks. The major adaptations that affect performance and ability to do work include:

- Increased oxygen carrying capacity of the blood
- Increased density of blood supply to and within muscle
- Increased oxygen carrying capacity of muscle
- Increased respiratory rate

Decreased oxygen at altitude reduces the maximal aerobic capacity of an athlete by 1% to 2% for every 100 meter (328 feet) rise above 1,500 meters (4,918 feet). Therefore, an elite endurance athlete may only be able to perform at 65% to 85% of maximal aerobic capacity at 10,000 feet when compared to sea level. Athletes that compete in anaerobic events, such as sprinters or weight lifters who perform brief (2-3 minutes) episodes of maximal effort events, may notice no initial difference in performance because sustained maximal oxygenation of muscle tissue is not necessary.

Acute Mountain Sickness

Acute Mountain sickness or AMS is typically a transient mild illness resulting from ascents to altitudes above 8,000 feet (2,440 meters) or ascents at a rate greater than 1,000 feet (305 meters) per day above 8,000 feet. Symptoms include headache, nausea, vomiting, fatigue and poor appetite. The symptoms usually disappear within a few days. Some individuals, however, may have to descend to gain relief. Life threatening complications of AMS include High Altitude Pulmonary Edema (HAPE) and High Altitude Cerebral Edema (HACE); both require immediate descent. The incidence and severity of AMS may be reduced by taking Acetazolamide (Diamox) 24 to 48 hours prior to and during an ascent. The dosage is 125 mg. by mouth, twice a day for two days, but this medication should only be given under the direction of a physician.

When participating in high altitude operations, you should report any of the following symptoms to your corpsman or medical officer:

- Cough or progressive shortness of breath
- Coughing up blood or frothy spit
- Progressive symptoms of headache
- Mental confusion or difficulty thinking
- Visual disturbances
- Lack of urination in excess of 8 hours
- Excessive irregular breathing

Other Factors that Hinder Performance at Altitude

Temperature

In general, temperature decreases 6.5° C for every 1,000 meter rise in elevation (or 11.7°F/ 3,280 ft.). At extreme altitudes (above 5,000 meters or 16,400 ft.), the combined effects of hypoxia and hypothermia may make sustained aerobic activity extremely difficult if not impossible.

Dry Air

Relative humidity falls as one ascends. Combined with the increased ventilatory rate experienced at altitude, significant water loss can occur from the normally moist respiratory passages. Cold temperatures will also cause

an increase in urinary output and together these two sources of water loss can result in rapid dehydration. Thirst cannot be used as a "measuring stick" for hydration status and personnel must constantly replace fluids with frequent water breaks.

Weight Loss

Most people who ascend to 13,000 feet (4,000 meters) or higher will experience a weight loss of 3% to 5% in the first 2 weeks at altitude. Some of this loss is muscle mass and appears to result from a decrease in the size of individual muscle fibers. There are several reasons for this weight loss:

- Increased energy expenditure
- Decreased appetite due to a direct effect of hypoxia and a decreased sense of taste
- Loss of body water
- Acute Mountain Sickness - Please refer to ***The Navy SEAL Nutrition Guide*** for dietary recommendations at altitude

Acclimation to Altitude

Prolonged exposure to altitude will bring about several physiologic changes and result in improved exercise tolerance at submaximal effort levels. At levels above 10,000 feet (3,050 meters), maximal aerobic capacity is limited and is lower than what would be measured at sea level. Below 10,000 feet, maximal aerobic capacity may approach sea level values, but usually only after a 2 week acclimation period. Because of this inability to achieve maximal aerobic capacity above 10,000 feet, elite endurance athletes may experience mild to moderate aerobic deconditioning with extended stays at altitude.

Training in Confined Spaces

During deployments or extended training exercises it is not uncommon to be confronted with conditions which may limit physical training routines. Complete cessation of physical training will result in a significant and rapid reduction in both strength and endurance capacity (see section on Deconditioning). Submarines and small assault craft probably create the greatest challenge, but under almost all circumstances where time is not a

limiting factor a reasonably well balanced training program can be maintained with a minimal amount of equipment. The following is a list of both aerobic and anaerobic training modalities for confined spaces:

- Calisthenics
- Pull-ups and dips
- Grip balls for grip strength
- Resistance equipment such as the Exergenie which imitate swimming strokes and are very light weight
- Therabands, another lightweight resistance tool to maintain strength in major muscle groups
- Jump rope
- Stair stepping (monotonous but good aerobic workout without need of special equipment)
- Plyoball
- Free weights
- Running in place

For larger platforms or forward operating bases with physical security limitations, the following equipment in addition to weights should also be considered:

- Climbers
- Cycle ergometer
- Rowing machine
- Stair climber
- Treadmill
- Ski machine
- Upper arm ergometer

Physical fitness equipment on a submarine should, at a minimum, include a cycle ergometer, a rowing machine and free weights.

The stationary cycle and rowing machines should have a performance monitor to display time, distance, etc., so that progress on stationary equipment can be charted and monitored. Platoons deployed under confined circumstances can reduce the monotony of stationary equipment and boost training morale by creating competitions. Monitoring and charting each members daily PT progress will help demonstrate results, encourage physical training, and maintain physical fitness.

Deconditioning

When a person is unable to maintain his exercise program, for whatever reason, detraining or deconditioning occurs rapidly. Numerous studies have investigated the effect of detraining on cardiorespiratory fitness, and significant reductions in work capacity has been noted within two weeks. A 25% decrease in maximal oxygen uptake has been reported after three weeks, which is equivalent to a 1% decline in physiologic function for each day of inactivity. In addition, the proportion and size of the Type II fibers have been shown to decrease with detraining. In contrast, maximal muscle strength appears to be more resilient to periods of inactivity. **A reduction in maximal capacity only means that it will be harder for you to do a given task than prior to deconditioning.** You will still be able to do the work. Remember:

The benefits of training are transient and reversible.

Although maximal aerobic capacity is not maintained without training, other key factors can lead to a decrease in aerobic capacity which will ultimately reduce your work capacity. These include:

- Increasing age
- High altitude
- Dehydration
- Loss of lean body weight

Chapter 12
Training and Sports Related Injuries

One of the hazards of being a SEAL or an athlete is becoming injured. In BUDS training, 1 out of 3 potential SEALs sustain an injury that may curtail training or require them to drop out of training. Sustaining either a sudden injury or an overuse musculoskeletal injury can mean loss of work days, forced rest, and pain for a period of days to weeks. More severe injuries result in scar tissue formation at the site of injury. Thus, the purpose of this chapter is to describe:

- Treatments for training-related injuries
- Reconditioning for return to full activity
- Types of training injuries
- Common mission-related injuries
- When to seek medical care

The goal is NOT to have you treat your own injuries, but rather to be informed so that you will seek appropriate help when needed. Central to the rapid recovery from training-related injuries is a step-wise reconditioning program which starts immediately after the injury. Such programs are designed to arrest the inflammatory process, promote healing, and accelerate the return to full duty.

Treatments for Training-Related Injuries

Sudden, traumatic, or acute injuries to the musculoskeletal tissue quickly result in inflammation, a process characterized by localized warmth, swelling, redness and pain. If left unchecked, however, the inflammatory process rapidly leads to:

- Tissue congestion
- Stiffness
- Weakness
- Decreased range of motion
- Loss of normal function

A highly successful Sports Medicine approach to accelerate the healing of any injury is to first decrease the inflammatory process (swelling, pain and warmth), and then increase the range of motion at the joint. **RICE** and **ISE** are the approaches used to achieve these goals.

RICE = Rest, Ice, Compression & Elevation

After decreasing inflammation by **RICE**, range of motion at the joint is achieved through continued use of ice (I), stretching of the injured ligament or tendon (S), and weight bearing exercises (E).

ISE = Ice, Stretching, & Exercise

Reduce Inflammation

RICE (rest, ice, compression, elevation) is appropriate for all strains and sprains. In general, if an operator cannot bear weight on the extremity, rest is indicated and x-rays to rule out a fracture should be completed as soon as practical.

- **"REST"** means applying no weight or only partial weight to the extremity; crutches should be used for locomotion. "Relative Rest" means decreasing activities that cause pain and replacing them with other activities that are pain-free.

- **"ICE"** means applying ice. This should continue until swelling has stabilized.
- **"COMPRESSION"** means applying an Ace wrap or similar compression wrap to the injured part for periods of 2-4 hours. **Never sleep with a compression wrap applied unless medically advised.**
- **"ELEVATION"** means placing the injured part above the level of the heart; this allows gravity to help reduce the swelling and fluid accumulation.

Application of Ice

Ice serves a variety of important roles in the treatment of training and sport injuries, including:

- Reduces swelling that accompanies inflammation
- Decreases muscle spasm and pain
- Allows for less painful range of motion
- Enhances blood flow back to the site after it has been removed

The operator should not wait for a medical evaluation before using ice.

All soft tissue or joint injuries, **except open wounds,** will benefit by **immediate application of ice** (See Table 12-1). Ice can be applied either passively or actively. Passive application is when you take some form of ice: crushed ice, ice slush, an ice pack, or snow and apply it to the injured body part. Active application is when you take the ice (perhaps in water frozen in a cup or bag) and massage the injured part with the ice. At home, a bag of frozen peas is an excellent way to passively ice the injured part, as the peas easily conform to the swollen area. After 20 minutes, the bag of peas can be tossed back into the freezer for reapplication later. The normal response to ice includes cold, burning, aching and finally numbness over the affected part. This progression occurs over 7-10 minutes.

Ice can be applied either passively or actively. Do not apply ice directly to the skin.

Table 12-1. Tips for Applying Ice: Passive and Active

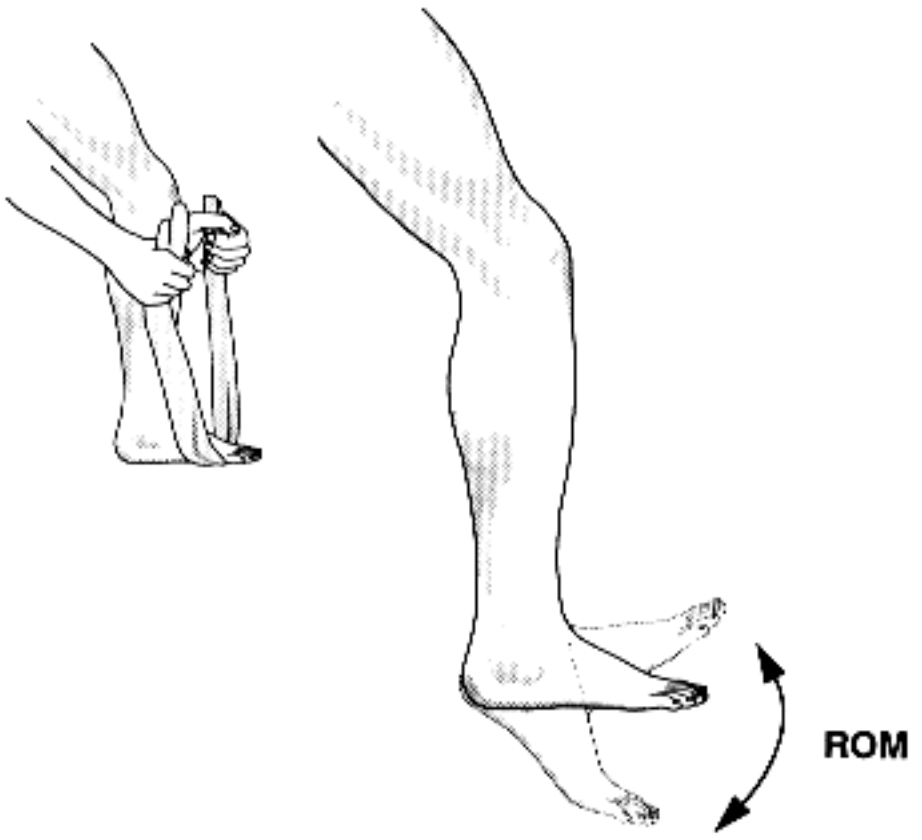
- **Apply ice to the area for 20 minutes as soon after the injury as possible.**
- **Repeat this every other hour the first day, then three times a day after the first day.**
- **Use ice until swelling decreases: usually 2 - 3 days.**

Caution: To prevent skin or nerve damage, do not keep ice on for more than 20 minutes, especially when applying to the elbow, wrist, or behind/side of the knee.

Range of Motion

The term range of motion is used to describe the extent to which a particular joint can be moved; achieving complete range of motion is the goal, but sometimes injuries restrict the range of motion. During the 20 minute icing session, you should attempt to move the injured part through a pain-free range of motion. Days later you can attempt a resistance activity which stresses the injured part while moving the joint through a range of motion that can be tolerated. An example would be moving the ankle up and down against resistance applied by holding a towel under the foot (Figure 12-1). Continued elevation and use of a compression wrap while doing these exercises will retard swelling.

Figure 12-1. Moving the Ankle Through its Range of Motion (ROM) with Resistance



Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

All of you have taken non-steroidal anti-inflammatory drugs (NSAIDs) at some point in your career, either as prescribed by a physician or on your own. NSAIDs are often used as the first treatment for overuse injuries because they are effective: NSAIDs decrease the symptoms due to inflammation (i.e., swelling, pain, tenderness, fever associated with injury). Although they are usually available over-the-counter, they are not a medication to take lightly. NSAIDs are used in training related injuries when there is inflammation caused by:

- Tendonitis
- Bursitis
- Sprains/Strains

In the case of an acute injury which involves bleeding (including bruising) or swelling, NSAIDs should not be started for 2 to 3 days or until the swelling has stabilized.

NSAIDs may cause side effects.

The most frequently reported side effects include:

- Gastrointestinal distress such as nausea, heartburn, or vomiting

- Gastrointestinal ulcers/bleeding
- Increased blood pressure
- Decreased ability of blood to clot
- Exacerbation of asthma
- Potential kidney damage with long-term use

Remember: NSAIDs should not be used, or should be used with extreme caution, in conjunction with alcohol, as both irritate the stomach. Table 12-2 provides a list of the most commonly prescribed (or over-the-counter) NSAIDs, with their generic and common brand name.

Table 12-2. Generic Names (and Common Names) for Various Non-Steroidal Anti-Inflammatory Agents

Generic Anti-Inflammatory Agents	
Aspirin (Bayer, Aspirin, Ecotrin)	Ketoprofen (Orudis)
Diclofenac (Voltaren)	Meclofenamate (Meclomen)
Diflunisal (Dolobid)	Nabumetone (Relafen)
Etodolac (Lodine)	Naproxen (Naprosyn, Anaprox)
Fenoprofen (Nalfon)	Oxaprozin (Daypro)
Flurbiprofen (Ansaid)	Piroxicam (Feldene, Antiflog)
Ibuprofen (Advil, Motrin)	Sulindac (Clinoril)
Indomethacin (Indocin, Indocin SR)	Tolmetin (Tolectin 200, Tolectin 600)

If you have stomach or other gastrointestinal tract problems, Tylenol (acetaminophen) may be a better choice for relieving muscle soreness than Ibuprofen- and Aspirin-based products.

Reconditioning for Return to Full Activity

After the pain and swelling are reduced and the desired range of motion is achieved, ask the physician, therapist or trainer to design a reconditioning exercise program with the overall goal of a **rapid return to full activity**. The exercises prescribed will be specific to the site and type of injury, and will work towards the following specific goals of maximizing:

- Flexibility
- Strength
- Endurance
- Power
- Speed
- Specific Duty Tasks

Each step should be successfully completed in a step-wise manner before returning to unrestricted activity. Definitions of most of these terms can be found in Chapter 1, however, the importance of each is described next.

- Strength and flexibility are closely linked. If flexibility is not balanced around a joint, or strength is maintained through only part of the range of motion, the risk of delayed healing or re-injury is high.

- With respect to endurance, the muscle quickly becomes deconditioned during the body's repair process and fatigues. Endurance is important in an injured ankle for example, as it may feel strong when rested but be prone to re-injury as the muscles and tendons around it become fatigued with activity. The strategies for any rehabilitation program include improving individual muscle endurance while maintaining cardiovascular or total body endurance.

- In terms of power, a weak, deconditioned muscle is prone to re-injury when called upon to perform a power move. Strategies for developing power include rapid motion against resistance, use of rubber bands, medicine balls or weight machines.

- Sustained speed provides for reconditioning the injured part to anaerobic (without oxygen) activity and coordination of movement. Interval training (e.g., sets of 440 yards over 90 seconds) several times per week is an excellent supplement to the rehabilitation of a lower extremity injury, provided the operator performs the activity below the pain threshold.

Continued use of ice and intermittent application of electrical stimulation, ultrasound and other therapeutic modalities will help accelerate the rapid return to full activity.

Return to Mission-Related Tasks

Ultimately, the operator must return to performing **specific tasks required to complete the mission**. This component of reconditioning MUST NOT be overlooked. Determine the specific mission-related tasks or training that puts the operator at risk for re-injury. These tasks should be practiced at slower speeds in a controlled setting, and proficiency should be demonstrated prior to a return to full duty. The ultimate goal is to return the injured operator to controlled physical activity in 4-7 days for a mild to moderate injury and 1 to 2 weeks for a severe strain or sprain.

General Guidelines for Returning to Physical Activity

A number of general rules apply during the repair and reconditioning period. These include the following:

- If the operator has pain with flexibility work, vary the degrees of motion.
- If there is pain with strength and power work, vary the repetitions and/or weight.
- If there is pain with endurance or speed work, vary the distance and/or time.
- If there is pain with specific mission-related tasks, vary the quickness and/or time required to complete these tasks.

In summary, rehabilitation and reconditioning places its greatest emphasis on rapidly decreasing pain and increasing range of motion about the injured joint by using **"RICE"** and **"ISE"**, followed by specific exercises to maximize flexibility, strength, endurance, power, and speed, and using ice as necessary.

Types of Injuries

A variety of injuries can be encountered during SEAL and other forms of physical training. In this section we will start with those problems that may be relatively minor and cause mild discomfort, and then proceed to more serious injuries that may limit your activities.

Training-Related Muscle Soreness

Delayed soreness in a deconditioned muscle is normal, and is caused by micro-injury. Pain and tenderness typically appear 12 to 48 hours after beginning a training session. Stiffness and soreness are worse after the cool down and resolve again after warming up. This normal process usually persists for 7-12 days and then disappears.

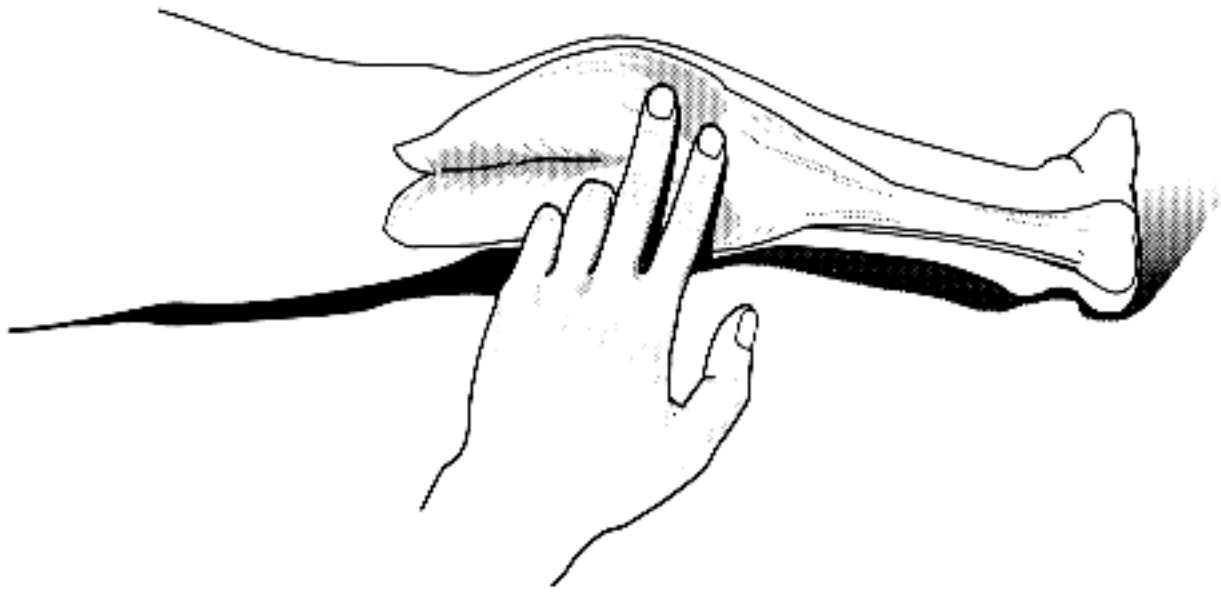
Table 12-3. A Process of Alleviating Muscle Soreness

Ice
Stretch
Extended Warm-Up
Work-Out
Stretch
Ice

Contusions

A blow to the muscle belly, tendon or bony prominence may cause swelling and bleeding into the tissue and form a contusion. The blood may coagulate and eventually form scar tissue, impeding normal function. Passive ice therapy needs to be started as soon as possible. After swelling has stabilized, start with active icing and then use **Cross Friction Massage**. This is a simple technique used to reduce the swelling and congestion. The thumb or index and long fingers are used to apply firm pressure perpendicular to the long axis of the tendon or muscle (Figure 12-2). The injured part is rubbed in this manner for 10 minutes, four times a day.

Figure 12-2. Technique of Cross-Friction Massage



Sprains and Strains

Ligaments attach bone to adjacent bone and can be damaged in a fall, an accident, or through overuse. Such injuries are called sprains and include acute back sprains, knee sprains, or ankle sprains. Sprains are graded as mild, moderate or severe. Mild sprains refer to overstretching and microtears of the fibers. A partial tear, with or without instability or looseness, is considered moderate. A severe sprain implies a complete or near complete tear of tendon fibers that results in looseness or instability at the joint.

A sprain is a damaged ligament.

Tendons attach muscle to bone. Muscle or tendon injury is referred to as a strain or tendonitis. Tendonitis, including achilles tendonitis, shoulder tendonitis, hamstring or quadriceps muscle strains, fall into this category.

A strain or tendonitis is an injury to a muscle or tendon.

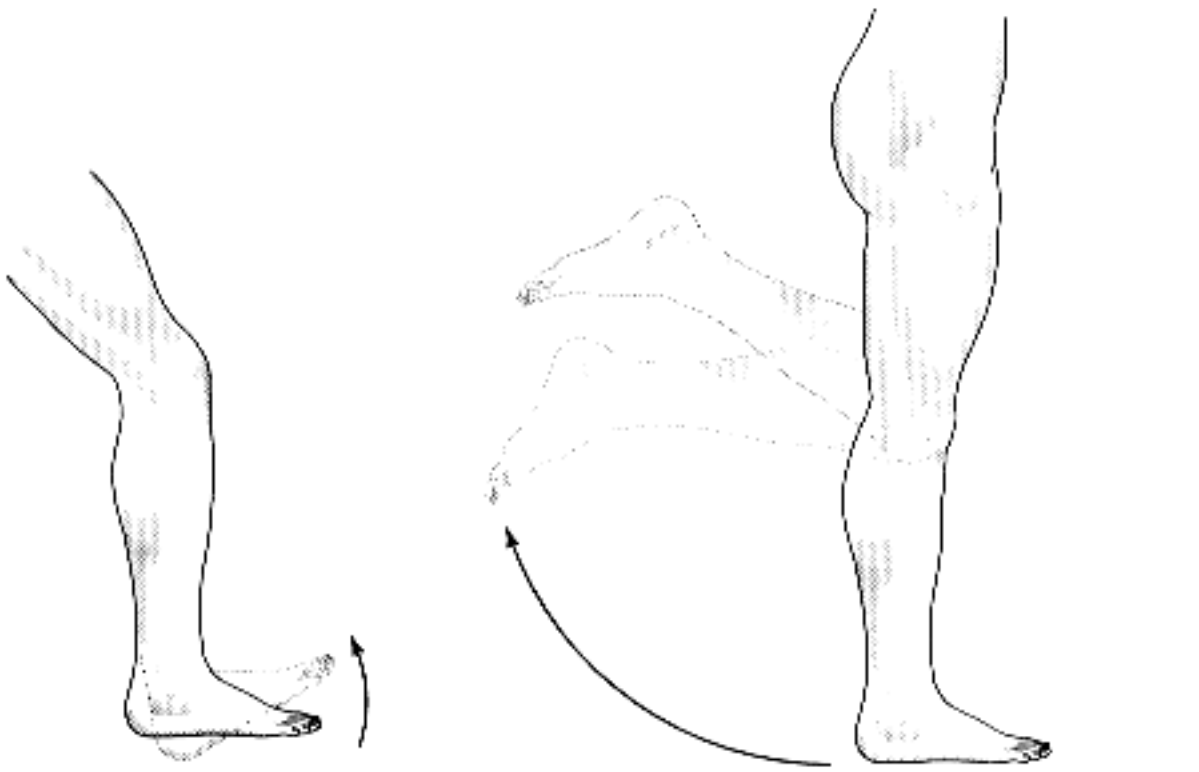
Mild to moderate lower extremity sprains and strains heal without residual problems if treated early. Primary treatment includes ice and NSAIDs, partial weight bearing with crutches as necessary, and early therapy to maintain range of motion at the joint.

Muscle Cramps

Muscle cramps are common and may be precipitated by prolonged physical activity, high heat and humidity (black flag conditions), dehydration and/or poor conditioning. Cramps are characterized by the sudden onset of

moderately severe to incapacitating pain in the muscle belly and may progress to involve other adjacent muscle groups. The first treatment consists of immediate rehydration with a fluid containing electrolytes. After beginning rehydration, further treatment should consist of grasping and applying pressure to the muscle belly and immediately putting the muscle on stretch until the cramp resolves. The calf muscle, for example, would be stretched by flexing the foot toward the head, whereas a thigh cramp would be treated by flexing the knee, bringing the foot to the buttocks. Pictorial representations of procedures for treating these cramps are presented in Figure 12-3. In addition to these procedures, adequate rest should help prevent recurrences.

Figure 12-3. Examples for Treating Painful Muscle Cramps in the Calf and Quadricep Muscles



Fractures

A true fracture involves a break or chip in the hard outer surface of the bone. With few exceptions, true fractures of the lower extremity require a period of immobilization in a cast and supervised care by a medical officer.

Stress fractures differ from true fractures and are most commonly seen in the load-bearing bones of the lower extremities, i.e. pelvis, femur, tibia, fibula and bones of the foot. They are caused by excessive strain on the bone. Bone constantly undergoes remodelling and repair in response to the stress of weight bearing. The repair process is accelerated by rest, and is slowed in

times of heavy exercise as with runs, hikes, marches and prolonged training. When the breakdown process exceeds the bone's ability to repair itself, a stress fracture may result. As the lower extremity bone becomes weakened, weight bearing activity, such as running, may cause a vague, achy pain at or near the weakened site. The first symptoms of stress fractures are initially poorly localized and often ignored. Later, as the process continues, the bone will become tender in a very localized area and will often ache at night or at rest. Ultimately, if left untreated, continued weight bearing may cause a true fracture within the weakened area of bone. Physical training factors which increase the risk for stress fractures include:

- A change in training surface (grass to asphalt, dirt to concrete)
- A change in shoe wear (worn out shoes or boots or new running shoes or new boots)
- An increase in physical activity (too much, too fast, too soon)

All suspected stress fractures should be evaluated and followed by the medical officer. Treatment for stress fractures include:

- Reduction or avoidance of impact and load bearing activities
- Partial weight bearing with crutches and advancing to full weight bearing when pain free

This process typically takes two to four weeks. Stress fractures are usually not casted when strict non-weight bearing or partial weight-bearing instructions can be assured. The reconditioning process should include swimming or water exercises (such as deep water running) to maintain flexibility and aerobic endurance. A program of lower extremity strengthening exercises should be started as soon as tolerated.

True fractures require a period of immobilization which varies depending on the bone involved. However, after the cast has been removed, the extremity should undergo a reconditioning program.

After the weight-bearing restriction has been lifted, the individual can begin a reconditioning program for running. A return to running should ideally be initiated on a treadmill. This allows the individual to customize increases in duration and speed while monitoring pain at the stress fracture site. A typical "return-to-running" program is presented in Table 12-4.

Table 12-4. Return to Running Post Injury

Return-to-Running
Run on soft and even surfaces- treadmill/track
Run 5 minutes at a slow pace
Increase time by 2 minutes every other day
When running pain-free for 15 minutes, increase pace
Advance to figure-of- eight runs: begin at 100 yard intervals and progress to tighter turns
Gradually increase distance (see Chapter 4)
Resume regular running program

Common Mission and Training Related Injuries

Given the nature of the SEAL's occupation, it is not surprising that injuries occur during training and mission-related scenarios. Clearly, the type of injury will depend on the specific physical tasks and the environments under which the tasks are performed. Table 12-5 presents a brief summary of some of the anticipated and common injuries that may occur during mission-related platforms. Other than these platforms, many of the injuries are a result of activities all SEALs participate in, namely swimming and running.

Table 12-5. Musculoskeletal Injuries Associated with Mission-Elements

Platform	Description of Injury
Steel Decks:	Knee Cap Pain (Patellofemoral Syndrome)
	Shin Splints
	Low Back Pain
High Speed Boats:	Knee Sprain with Effusion
	Back Pain
	Quadriceps Strain
	Tendonitis below Knee Cap (Patellar)
Parachute Jumps:	Fractures
	Patellar Tendonitis
	Low Back Strain/Sprain
	Muscle Strain
Confined Space (Submarine):	Header (Head Blow)
	Shin Contusions
Troop Transport:	Shin Splints
Rappelling/Rock Climbing:	Rope Burns
	Elbow Tendonitis
	Abrasions of the Fingers
	Biceps Tendonitis
	Back Strain
	Shoulder Sprain
Fast Roping:	Deep Heel Bruises

Swimming

Swimming is a non-impact activity involving maximum tension on the muscle-tendon unit. Most injuries result from overuse and over training, rather than from one traumatic event. Consequently, once an injury occurs, healing can prove difficult.

The older, experienced operator, despite a high skill level, faces the added challenge of tendons and joint capsules that are less resilient, muscles that take longer to warm up, and flexibility which is more difficult to maintain. All of these factors can lead to an increased risk of overuse and acute injury in this age group. The most common injuries arising from endurance swimming are sprains, strains and overuse injuries of the shoulder, knee and back.

Stroke-Associated Injuries

Freestyle, butterfly, and backstroke place a great amount of stress on the shoulder joint. Use alternate or bilateral breathing on freestyle and be sure to get plenty of roll on backstroke. Before beginning a butterfly set, be sure you are well warmed up. This will allow the shoulder to stay in a more neutral position during the activity of arm recovery and this neutral position helps prevent what is known as ***"impingement syndrome"*** (described later in Table 12-8).

Freestyle swimming and kicking with a kickboard places a great amount of stress on the low back because of hyperextension; doing the backstroke relieves the stress. A pullbuoy is also helpful as it raises the hips and allows the spine to assume a more neutral posture.

Kicking with fins may aggravate the knee (especially the knee cap) and result in a degenerative condition known as ***patellofemoral syndrome,*** which commonly afflicts athletic individuals (described later in Table 12-8).

The breaststroke kick helps balance the knee joint by increasing muscular tone on the inside of the quadriceps muscle, and serves to balance the effect that running has: increasing muscular tone on the outside portion of the quadriceps muscle. However, the breaststroke may actually intensify ***iliotibial band syndrome*** (described later in Table 12-8). Swimmers may need to avoid doing breaststroke if they feel increased pain over the outside of the knee.

Running and Hiking

Running and hiking work large muscle groups and enhance cardiovascular fitness in a short period of time. Hiking transmits a force to the spine of approximately three times load-bearing weight. Running transmits an impact force to the spine of up to five times load-bearing weight. These forces are minimized with good body mechanics, shock-absorbing shoes and cross-training for overall fitness. Table 12-6 outlines common running injuries.

Table 12-6. Common Running Injuries

Name of Injury	Description of Injury
Plantar Fasciitis	Inflammation and tightness of thick fibrous band on sole of foot.
Achilles Tendonitis	Inflammation of calf tendon or "heel cords" especially at insertion into heel.
Iliotibial Band Rub	Pain on outside or lateral aspect of knee or high on outside of hip.
Bursitis	Inflammation or irritation of various bursal sacs about inner or medial portion of knee, or behind the heel of the foot.
Shin Splints	Pain along medial aspect of lower third of tibia, worse in morning, resolves after warming up. Resolves with cooling down after running.
Back Strain/Sprain	Results from impact loading of spine.

Knee Sprains

A complete discussion of knee injuries is beyond the scope of this text. Medial and lateral collateral ligament sprains can be placed in a range-of-motion (ROM) brace to allow early flexion and extension while protecting the damaged ligament.

A knee immobilizer brace that extends and immobilizes the knee straight out should be used with caution. Within 72 hours of using this type of brace, the thigh muscle is weakened and atrophied (muscle wasting as a result of disuse). However, this type of brace must be used with patella (knee cap) fractures and patellar dislocations. While in this brace, strengthening exercises should be started as early as possible to avoid muscle atrophy.

Ankle Sprains

Ankle sprains are ideally treated in an aircast or similar splint. Ice, cross friction massage, partial weight-bearing, and early range of motion is allowed while protecting the injured ligament. Some severe sprains may require surgical intervention.

Overtraining Syndrome

The most common physical conditioning error for the SEAL operator is overtraining. Overtraining is exactly what the word implies, a condition caused by:

Too Much Physical Activity

Physical training for the operator differs from programs designed for elite athletes. The athlete in professional or college sports has an off-season to rest injured muscles and tendons, utilize physical therapy, maximize strength and flexibility, and finally cycle back into his sport. The SEAL team operator has no such luxury and training is a full time job. Typically he trains to peak levels year round. It is this repetitive, peak performance conditioning schedule that may lead to overtraining and overuse injuries.

The **OVERTRAINING SYNDROME** can present with a wide range of physiologic or psychological symptoms which vary widely among individuals (See Table 12-7). Overtraining is generally associated with endurance sports such as swimming or running.

There is no good laboratory or biochemical marker for overtraining syndrome. The **BEST INDICATORS** are resting heart rate in the morning and assessment of mood. Resting heart rate taken daily just before getting out of bed, and monitored over time will give some indicator of fitness as well as fatigue. Individuals who are overtrained will show a resting heart rate which is 10-15 beats per minute higher than baseline when measured over a period of several days. A day or two of abstaining from physical activity

should show a return to baseline. The operator who continues endurance activities despite the baseline elevation in heart rate will only become more overtrained.

Table 12-7. Characterization and Symptoms of Overtraining Syndrome

Major Symptoms of Overtraining	
Decreased performance and muscle strength	Decreased Capacity to make decisions
Burn-out or staleness	Difficulty with concentration
Chronically fatigued	Angry and irritable
Lacking motivation	Muscle soreness
Disturbances in mood	Increased distractibility
Feelings of depression	Difficulty sleeping
Change in heart rate at rest, exercise and recovery	Increased susceptibility to colds or other illnesses

Changes in mood or mood swings may also be a signal that the individual is overtraining. Little data exist on mood assessment in the SEAL community. Typically, assessment of mood is accomplished with questionnaires. However, individuals who are overtraining and give an honest assessment of mood will consistently report feelings of frustration, anger, depression or an inability to feel anything at all.

Cross-training, rest days, monitoring of morning heart rate, mood assessment, and taking time off from certain physical activities will reduce overtraining errors.

Overtraining differs from "overwork," which is the temporary deterioration of performance capabilities due to an increase in the volume or intensity of training. Overwork is what typically happens to BUDS students. Physical and mental performance deteriorates in the most demanding parts of the training schedule, only to rebound quickly as the schedule lightens up.

Unlike overtraining, the overworked individual is able to show an increase in physical performance when faced with a greater workload or physical challenge.

When to Seek Medical Care

Table 12-8 provides the symptoms, preventive measures, and selected treatment modalities for common training and mission-related musculoskeletal injuries. This list is presented for information and to help you determine whether you need to seek medical treatment. However, there are numerous conditions which demand immediate medical attention.

Conditions Requiring Immediate Evaluation by Medical Personnel:

- Back pain that radiates into the thigh, leg or foot
- Severe pain
- Numbness
- Joint dislocation
- Suspected fracture
- Any lower extremity injury in which the individual is unable to bear weight
- Pain which limits activity for 3 to 5 days
- Any hip pain which causes a limp

Table 12-8. Symptoms, Prevention, and Treatment of Common Training- and Mission-Related Injuries

Injury	Symptoms	Prevention	Treatment
Plantar Fasciitis	Pain in sole of foot just in front of heel; stiffness in sole with first steps of morning.	Stretch Achilles and foot after runs, hikes; massage sole of foot; firm shoes;1/4" heel lift; arch supports.	Stretch the Achilles tendon and foot on incline board; tape sole instep; massage, ice sore spot; place 1/4" heel lift in shoes.
Metatarsal Stress Fracture	Pain in long bones of foot, especially 2nd or 3rd; worse with weight bearing; aches at night.	Avoid training too much, too fast, too soon; take care when transitioning to new training surfaces (grass to asphalt); different footwear (old shoes, new boots).	Decrease amount of running or hiking; avoid full weight-bearing, use crutch or cane; seek medical evaluation.
Shin Splints	Pain at lower third inner tibia; worse with first steps of running or hiking; usually after long or hard runs or hikes.	Good shoe/boot wear; stretch before and after runs/hikes; pronators (flat feet) should use arch supports.	Ice to painful area before and after run, hike; ankle strengthening exercises, calf stretches, arch supports; medical evaluation for pain longer than 12 days.
Iliotibial Band Rub (ITB)	Pain at outside portion of hip or knee; gets worse several minutes into run.	ITB stretches; discard broken down shoes; use running shoes with wide heel base; check leg length differences.	Ice to painful sites. ITB stretches. Hamstring and quad stretches. Heel lift for leg length difference.

Table 12-8. Symptoms, Prevention, and Treatment of Common Training- and Mission-Related Injuries

Injury	Symptoms	Prevention	Treatment
Muscle Cramps	Sudden severe pain in muscle belly, causing stiffness and loss of motion.	Maintain hydration/ acclimatization protocols; stretch at first hint of muscle tightness.	Grasp and tightly compress muscle belly with both hands; stretch muscle to maximum tolerable length until cramp resolves.
Achilles Tendonitis	Pain at back of heel along heel cord; worse with running and climbing.	Incline board stretch of Achilles; over-the-counter arch supports; stretch after all runs.	Ice for 15-20 minutes, every hour when possible; incline board stretch; cross friction massage.
Patellofemoral Syndrome	Knee pain localized under or around the knee cap; worse with going up/down hills or after prolonged sitting.	Quadriceps stretching/ strengthening exercises; hamstring and ITB flexibility exercises; check foot for biomechanical abnormalities (over pronation).	Ice and range of motion to acute injury; NSAIDs for 5 to 7 days; stretching/strengthening program. Arch supports or insert for over pronators.
Rucksack Palsy	Weakness, pain, and/or numbness of upper extremities or shoulders.	Correct load distribution; adjustment of straps as needed. Correct padding.	Avoid heavy load-bearing for 2 to 3 weeks; NSAIDs for 5 to 7 days.
Foot Blisters	Localized pain and redness: "hot spots caused by friction rub; clear fluid vesicle layer.	Shoe insoles (Spenco) Adaptive training to toughen skin; Change wet socks; Moleskin to blister-prone areas.	Cover blister with clean bandage and/ or moleskin; apply antiseptic to unroughen blister.

Table 12-8. Symptoms, Prevention, and Treatment of Common Training- and Mission-Related Injuries

Injury	Symptoms	Prevention	Treatment
Ankle Sprain	Pain, swelling, loss of function after turning the ankle.	Ankle stretching and flexibility exercises, ankle braces.	If unable to bear weight, seek medical evaluation. Ice 20 min. every hour; compression wrap from toes to lower leg; leaving no gaps. Elevation: elevate foot 18" off ground; motrin, aspirin for pain; partial weight bearing using cane or crutch; seek medical evaluation for pain lasting longer than 3 days.
Medial Epicondylitis	Pain at inner bony aspect of elbow; worse with wrist extension.	Caution with aggravating factors: narrow-based hand placement for push-ups or wrist extension under resistance; generalized wrist-strengthening program.	Ice to bony prominence; wrist stretching/strengthening exercises; cross friction massage; avoid aggravating factors.
Heat Stroke	Hot, dry, flushed skin, high body temperature, altered level of consciousness, weakness, incoordination.	Hydration, stepwise acclimation to environmental conditions.	LIFE THREATENING MEDICAL EMERGENCY. Replace fluids; if possible, cool water immersion in the field; ice packs to arm pits, groin, temple; transport immediately to medical facility.
Heat Exhaustion	Cool, damp skin; nausea, weakness, fatigue, poor concentration.	Maintain hydration, during exercise in all weather; avoid Black Flag conditions.	Remove excess clothing, replace fluids, cool body with water immersion, ice packs, transport to medical facility.

Chapter 13
Harmful Substances that Affect Performance

SEALs and other elite athletes are always looking for ways to improve their physical performance and gain a competitive edge to enhance their success in missions or competition. Often there is a temptation to seek other ways of increasing your capabilities, including trying various ergogenic agents or chemical substances, either natural or man-made, that promise to give an edge. This chapter reviews some of those chemicals that may give you a temporary edge, but the minor improvements you might see in the short-term can be harmful in the long-term. The goal of this chapter is to inform you of the detrimental effects and the legal consequences of using chemicals as performance enhancers. This chapter is not intended to support or promote the use of these chemicals for improving your performance.

Anabolic/Androgenic Steroids

Anabolic/Androgenic steroids, hereafter referred to as **AAS**, have been used by athletes to improve performance for more than 30 years. The non-medical use of AAS is widespread among athletes engaged in power sports such as power-lifting, bodybuilding, football and rugby. Their popularity stems from their perceived contribution to increase muscle bulk and strength and to improve competitiveness. There are more than one million estimated users of AAS in the United States alone. Approximately 2% of athletes between the ages of 10 and 14, and 5% to 10% of high school athletes have used AAS, even though their use is prohibited. In addition, approximately 5% of college athletes currently use AAS. Because of legal and

administrative issues it is difficult to estimate the number of Olympic and professional athletes currently using the drugs. However, a number of Olympic Gold Medalists have had their medals withdrawn for using such substances. The use of AAS for improved competitiveness violates ethical principles and is strictly prohibited by the military services as well as the United States Olympic Committee (USOC) and other national sports governing bodies.

How do Anabolic Steroids Work?

AAS are synthetic derivatives of the hormone testosterone, which is responsible for the development of male characteristics. The pituitary gland in the brain controls the production of testosterone in the male testes. Testosterone has both androgenic (masculinizing effects) and anabolic (tissue-building) properties. The main functions of testosterone in an adult are to:

- Promote secondary male sex characteristics, such as hair patterns and deepening of voice
- Increase muscle mass
- Initiate and maintain sperm production

Anabolic steroids were developed by structurally altering testosterone to reduce its breakdown, and to maximize its tissue-building (anabolic) effects. The more commonly used anabolic steroids are listed in Table 13-1. This class of steroids was first used therapeutically to treat certain disorders of the blood, bone mass deterioration, protein wasting states, and as a replacement therapy for male children deficient in testosterone.

AAS should not be confused with corticosteroids which act as anti-inflammatory agents and are used to treat a variety of medical conditions.

Table 13-1. Commonly Used Anabolic/Androgenic Steroids

Generic Name	Street Name
Bolasterone	
Boldenone	Vebonol
Clostebol	Steranobol
Dehydrochlormethyltestosterone	Turnibol
Fluoxymesterone	Android F, Halotestin, Ora-testryl
Mesterolone	Androviron, Proviron
Metandienone	Danabol, Dianabol
Metenolone	Primobolan, Primonabol-Depot
Methandrostenolone	Dianabol
Methyltestosterone	Android, Estratest, Methandren
Nandrolone	Durabolin, Deca-Durabolin
Norethandrolone	Nilevar
Oxandrolone	Anavar
Oxymesterone	Oranabol, Theranabol
Oxymetholone	Anadrol, Nilevar, Anapolon 50
Stonozolol	Winstrol, Stroma
Testosterone	Malogen, Malogex, Delatestryl
Human Growth Hormone	Human Growth Hormone

How Anabolic Steroids Alter Metabolism

In a progressive weight training program, muscles are challenged to grow in size and strength in order to meet the increasing workload placed upon them. The structure of muscle consists chiefly of protein. Strength and size gains are achieved primarily by increasing the amount of protein inside the muscle. Protein requirements of the human body are determined by a complicated and difficult procedure called nitrogen balance. The body must ingest an adequate supply of protein in the diet to process, absorb, and retain nitrogen to support the weight training.

The stress of intensive strength training induces a catabolic state. In this state, muscle protein is broken down, but a state of anabolism or muscle protein formation follows. By an unknown mechanism, AAS enhance the anabolic processes. Anabolic steroids improve the body's nitrogen balance by reversing the catabolic state; thus muscle protein synthesis is supported. AAS are also believed to directly stimulate the growth of new protein within muscle cells and the cells of other tissues. A detailed description of protein needs is provided in *The Navy SEAL Nutrition Guide*. In brief, the daily requirement for protein is 0.6 to 0.8 grams per pound of body weight. Protein intakes in excess of 0.8 grams per pound do not cause an increase in protein stores, but such intakes do increase the work of the kidney. The kidneys are responsible for excreting the waste products from digestion of excess protein.

Purported Beneficial Effects of Anabolic Steroids

There are several purported effects of AAS which may be beneficial to athletes. The first is an increase in lean body mass. In muscle cells this would result in an increase in production of proteins responsible for muscle contraction, energy production and energy storage. The second is strength. AAS may regulate the movement of calcium from within the cells, which could lead to an increase in the speed and force of contraction. Another potential benefit of AAS is an increase in aggression which may allow the athlete to do more work. At times this may be desirable whereas in other situations it may actually compromise a mission. Overall, the potential beneficial effects of anabolic steroids include:

- Increased muscle size
- Increased muscle strength
- Increased aggression

- A perception of improved performance
- Increased motivation
- Decreased fatigue

Adverse Effects of Anabolic Steroids

The use of anabolic steroids is strongly associated with numerous undesirable effects, many of which may not be predictable on the basis of the dose or frequency with which they are used. These potentially dangerous substances are usually taken without supervision, although this is illegal, and there have been many reports of serious illness or deaths resulting from their use. AAS may falsely increase the perception of strength and cause an individual to lift heavier weights than he should. This often results in torn muscle and ruptured tendons, in particular tears of the biceps and deltoids, because **the strength of muscles increases more rapidly than the strength of tendons.** The immune system may be impaired, but this abnormality may not be detected until after its use. Importantly, transmission of hepatitis B and AIDS can occur from needle or drug sharing. Various cancers have also been associated with AAS use. Liver, cardiovascular, hormonal, reproductive and nervous systems are most affected, but other systems may also be adversely affected.

The most frequently reported negative effects are listed in Table 13-2. Many of these are reversible when steroids are discontinued, but some can be permanent or irreversible. If used in young athletes, these agents limit final height because of the early termination of bone growth. Clearly, the health risks far outweigh any benefits anabolic steroids may confer. The most common problem includes liver dysfunction. This serious medical problem occurs frequently in users of oral AAS and causes jaundice. Peliosis hepatitis, a condition where blood filled cysts develop within the liver, has also been reported.

The cardiovascular effects of AAS in men and women include high blood pressure, increases in serum cholesterol concentration and serum LDL (the bad cholesterol), and a decrease in serum HDL (the good cholesterol). Heart attacks, strokes, and blood clots in the lungs have also been reported in AAS users.

The hormonal effects of AAS use in the male include decreased natural testosterone production, decreased sperm count, production of abnormal sperm and shrinkage of the testes. Breast tissue enlargement is also common, as are acne, glucose intolerance, and baldness. Women AAS users have slightly different hormonal responses, including thickening of the vocal cords with resultant deepening of voice, male pattern baldness, facial hair growth

and enlargement of the clitoris, all of which are irreversible. Breast tissue shrinkage, menstrual irregularities, infertility, glucose intolerance and acne are also common in women who use AAS.

Perhaps the most significant short-term adverse effects are the psychologic changes associated with AAS use. For both men and women AAS users, increased aggression, rage reactions ("roid rage"), altered libido, anxiety and panic disorders, psychosis ("bodybuilder's psychosis"), depression, mania and addiction have been noted. Again, these effects are undesirable for tasks required by SEALs. It is extremely important to note that:

Many of the side effects may cause permanent impairment, and some are potentially, if not outright, lethal.

Table 13-2. Adverse Effects of Anabolic Steroids in Men: Physiologic and Psychological

Physiological Effects	
Irreversible	
Breast enlargement	Atrophy of the testicles
May Be Reversible	
Decreased sperm production	Accelerated baldness
Decreased testosterone levels	Elevation of cholesterol
Liver tumors	High blood pressure
Acne	Liver dysfunction
Psychological Effects	
Irritability	Depression
Mood swings	Addiction
Mania	Psychosis
Excessive aggressiveness	

Legalities of Steroid Use

There are also legal ramifications associated with AAS use. Since early 1991, AAS and related compounds have been classified as drugs controlled by the Food and Drug Administration. These drugs have a high potential for physical and psychological dependence as well as their catabolic effects on various body systems. Transportation or distribution of these agents is punishable by fines of up to $500,000.00 and/or a prison sentence of up to 15 years. The military, as well as most sports governing bodies, (IOC, USOC, NCAA, NFL), ban the use of AAS. Users who are detected using such agents face significant penalties.

AAS screening is now performed in the military along with routine random drug screening. Oral AAS can be detected by urine drug screening from 2-14 days after use. Some forms may be detected for weeks to months after injection. There is zero tolerance for possession and use of AAS in the military, unless appropriately prescribed by medical personnel. Any violation would be punishable under Article 92 of the Uniform Code of Military Justice (UCMJ). If found guilty, that individual may also be processed for administrative separation from the military.

Medical Uses of Corticosteroids

As stated previously, AAS should not be confused with corticosteroids. Corticosteroids, or glucocorticoids, are a category of synthetic hormones used to restrain inflammation and to control itching. They are commonly used topically for skin disorders, and given by injection into joints which are inflamed. Corticosteroids have been classified by the USOC as subject to restrictions; a physician must declare the intent to treat prior to a competition.

Other Harmful Chemicals

Growth Hormone

Human growth hormone (hGH) is a hormone produced in the brain. The hormone is commonly used to increase the height of very short children and until recently to increase strength in the elderly. Athletes have been known to use hGH at a black market cost of about $2,000 for an 8-week course. The known effects of hGH in the athlete are shown in Table 13-3.

Table 13-3. Physiologic Effects of Growth Hormone

Increases muscle mass
Increases fat breakdown for energy
Conserves blood glucose and muscle glycogen storage
Increases height in the skeletally immature individual
Increases size of hands, feet, and jaw
Enhances healing of musculoskeletal injuries

Unfortunately, the increase in muscle mass does not increase muscle strength as much as strength training. No increase in height has been seen in a fully grown person, however, hGH may increase hand, foot, jaw and body size. There is little known about the adverse effects of hGH use in the normal athlete, but the skeletal muscle growth may be abnormal and therefore the muscles may be weak. Given that hGH use is banned by the military, as well as the IOC, NFL, NCAA and most sports governing bodies, it should not be used.

Clenbuterol

Clenbuterol, a drug used by veterinarians to increase muscle mass in livestock, is being used by many athletes, primarily those in strength-related sports. However, increases in muscle strength have not been shown in humans. In addition, there are numerous adverse side effects, including rapid heart rate, muscle tremors, headaches, nausea, dizziness, fever and chills. Although technically classified as a β_2-agonist, it is officially considered an anabolic agent by the USOC, and is thus on their list of prohibited substances.

Stimulants

Stimulants are agents which increase arousal of the central nervous system (CNS). These agents are used medically in the treatment of various conditions, including depression, narcolepsy (sudden and irresistible onset of sleep), and in the treatment of diseases of the bronchial tubes. Athletes often abuse a number of stimulants because they think their performance will improve. Most stimulants are banned by the military as well as most sport governing bodies; these agents are also measured in routine random drug screening tests. The major classes of CNS stimulants are:

- Amphetamines
- Ephedrine
- Caffeine

This section will discuss only those agents which are illegal and can produce harmful effects.

Amphetamines

One class of stimulants is the **Amphetamines**. The term amphetamine also includes methylamphetamine, dimethyl-amphetamine, and benzylamphetamine which are metabolized to amphetamine after ingestion. In the 1960's, these drugs were widely used by athletes in the belief that they improved strength and endurance. Stimulants such as amphetamines and many over-the-counter amphetamine "look alikes" have pronounced effects throughout the body. Taking these agents will result in the physiologic and psychological effects noted in Table 13-4 and Table 13-5. As can be seen, these effects are the same ones which occur normally without stimulants when you are asked to undertake dangerous missions.

Table 13-4. Reported Physiologic Effects of Amphetamines

Increases heart rate
Increases cardiac output
Elevates blood pressure
Increases conversion of glycogen to glucose
Elevates serum glucose
Elevates serum free fatty acids
Dilates blood vessels in muscles
Constricts blood vessels in the skin
Increases muscle cell excitability

Amphetamines can mask symptoms of fatigue. They may restore reaction time in a weary athlete, but cannot improve reaction time or diligence in a well rested and motivated athlete. The potential beneficial effect is most marked when performance is reduced by fatigue or lack of sleep.

Exercise itself induces these same effects, so amphetamines have not been shown to make a net contribution to the physiological mechanisms which support athletic performance. They clearly make no difference in maximal aerobic capacity, but there is some evidence for small increases in speed and the time it takes to fatigue in endurance events. It could be that the primary performance enhancement benefit rendered by amphetamines lies in their psychological effects as listed in Table 13-5.

Table 13-5. Psychological Effects of Amphetamines

Delayed onset of the sensation of fatigue
Increased alertness
Mood elevation
Increased aggression
Improved self-confidence
Suppression of inhibitions

Perhaps more so than with many drugs, the use of amphetamines is associated with detrimental side-effects that cannot only erode athletic performance, but can also harm health and threaten life. These are listed in Table 13-6. Because of these side-effects and the illegality of their use, these drugs must be avoided.

Table 13-6. Adverse Effects of Amphetamine Use

	Nervous System Effects	
Acute Effects	Irritability	Confusion
	Insomnia	Paranoia
	Restlessness	Delirium
	Dizziness	Uncontrolled Aggression
	Headache	Dry Mouth
	Vomiting	Abdominal Pain
Chronic Effects	Uncontrolled Involuntary Movements	Addiction
	High Blood Pressure	Cerebral Hemorrhage

Ephedrine and Pseudoephedrine

Ephedrine, and its most notable derivative, pseudoephedrine, are adrenaline-like CNS stimulants found in many over-the-counter cold and hay fever preparations as well as in many herbal products, in particular the herb known as Ma Huang. Like clenbuterol, ephedrine is a ß-agonist, and has properties similar to that of amphetamines. It is often combined with caffeine. At doses higher than found in over-the-counter medications, restlessness, muscle tremors, anxiety, and headaches are frequently produced. Ephedrine is not widely used in sports to improve performance and there is no scientific evidence that it does. However, many people have used ephedrine and Ma Huang to lose weight through an increase in resting metabolic rate and metabolism of fat. Recently a number of people have died from drinking tea containing ephedrine. Given that it is banned by the OSOC and a potentially life-threatening agent, it should not be used.

Erythropoietin

Erythropoietin (EPO) is used by endurance athletes to improve performance. One type of EPO, called rEPO or rhEPO, is used to treat a number of blood diseases. Athletes use rEPO because it increases the red blood cell count by stimulating red blood cell production and speeding red